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HATCHING DATES OF WATERFOWL IN NEW YORK[1]

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ABSTRACT

Hatching dates were calculated for nearly 1,900 waterfowl broods observed while less than 3 weeks old. For the principal species, the hatching peaks were found to be: black duck, mid-May through early June; mallard, late May through mid-June; wood duck, mid-May through late June; and blue-winged teal, early June. Within these ranges, hatching dates in a given year tended to be earliest in the lower Hudson Valley, followed by Long Island, the Erie-Ontario Lowland, the middle Hudson Valley, the Southern Tier and the central Adirondacks in that order. There was considerable overlap, however. Little difference were noted from year to year for the same species in the same area.

Knowledge of hatching dates of waterfowl is useful in planning field studies and interpreting findings. Since 1936 a substantial number of records indicative of hatching dates for waterfowl in New York has been accumulated through observations by both research and management personnel. This paper is a summation and analysis of these.

Few specific hatching dates for individual nests were obtained. The available data very largely represent calculated dates derived from observations of broods for which the age of the ducklings was estimated. Prior to 1953, brood observations were recorded in terms of estimated age in weeks. After that, they were recorded in terms of age classes based on plumage development as described by Marshall *et al.* (1953) and Gollop and Marshall (1954). In both instances, the records were back-calculated to determine the probable hatching date to the nearest week.

Experience indicated that the most reliable records for this purpose were those for broods up to 3 weeks of age. Therefore, only these were used. In addition some groups of records, collected by untrained personnel, showed an improbable degree of variability, and these were discarded.

RECORDS FROM PROJECT STUDY AREAS

Waterfowl research involving intensive observation of broods was

[1] A contribution of Federal Aid in Fish and Wildlife Restoration Project W-39-R.

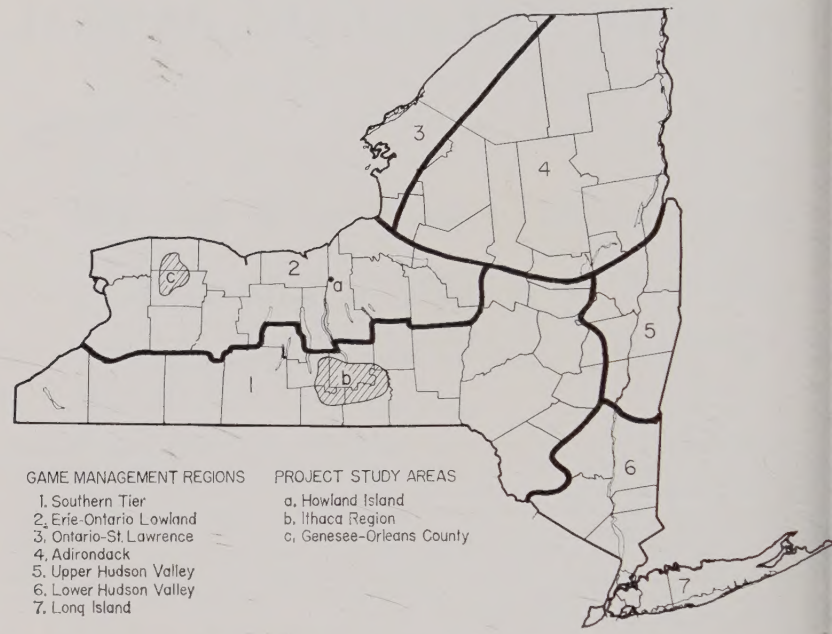

Figure 1. Location of project study areas and game management regions from which data on waterfowl hatching dates were obtained.

carried out on a number of areas, chiefly in central New York (Figure 1). Although surveys were not made each year they covered the period from 1936 to 1956.[2] The fieldwork was done from May through mid-August so that both early- and late-hatching broods were well represented in the data. As a background for judging the age of broods, research personnel engaged in these surveys had had considerable opportunity to become familiar with known-age mallard ducklings on game farms.

HOWLAND ISLAND AREA

Howland Island is situated in the Seneca River in Cayuga County. Waterfowl brood surveys were made there and on associated marshes in 1936, 1937, 1942, 1953, 1954 and 1955. The data (Table 1 and Figure 2) indicate that, of the four commonly nesting species, the black duck reached the peak of its hatching period first and that by the end of the first week of June more than half the season's black duck broods were off the nest. There appeared to be no real difference in the hatching period for mallards and wood ducks, and it was early in the second week of June before half the broods of these species had hatched. For blue-winged teal, few

[2] In 1936 and 1937 brood surveys were made by selected CCC crews under the direction of a Department biologist. From 1939 to 1942 the work was done under Federal Aid Project W-1-R. Later studies were made under Project W-39-R.

AND 1955

Broods observed	Calculated distribution by period										Total
	Prior May 18	May 18–24	May 25–31	June 1–7	June 8–14	June 15–21	June 22–28	June 29–July 5	July 6–12	After July 12	
Black duck											
Number	4	15	21	20	18	5	5	5	....	....	93
Percentage											
By period	4.3	16.1	22.6	21.5	19.3	5.4	5.4	5.4	....	....	100.0
Cumulative	4.3	20.4	43.0	64.5	83.8	89.2	94.6	100.0	....	....	100.0
Mallard											
Number	11	9	12	21	21	9	10	15	2	2	112
Percentage											
By period	9.8	8.0	10.7	18.8	18.8	8.0	8.9	13.4	1.8	1.8	100.0
Cumulative	9.8	17.8	28.3	47.3	66.1	74.1	83.0	96.4	98.2	100.0	100.0
Wood duck											
Number	9	17	30	34	32	22	13	16	13	5	191
Percentage											
By period	4.7	8.9	15.7	17.8	16.8	11.5	6.8	8.4	6.8	2.6	100.0
Cumulative	4.7	13.6	29.3	47.1	63.9	75.4	82.2	90.6	97.4	100.0	100.0
Blue-winged teal											
Number	....	....	3	7	10	10	6	6	2	1	45
Percentage											
By period	....	....	6.7	15.7	22.2	22.2	13.3	13.3	4.4	2.2	100.0
Cumulative	....	....	6.7	22.4	44.6	66.8	80.1	93.4	97.8	100.0	100.0

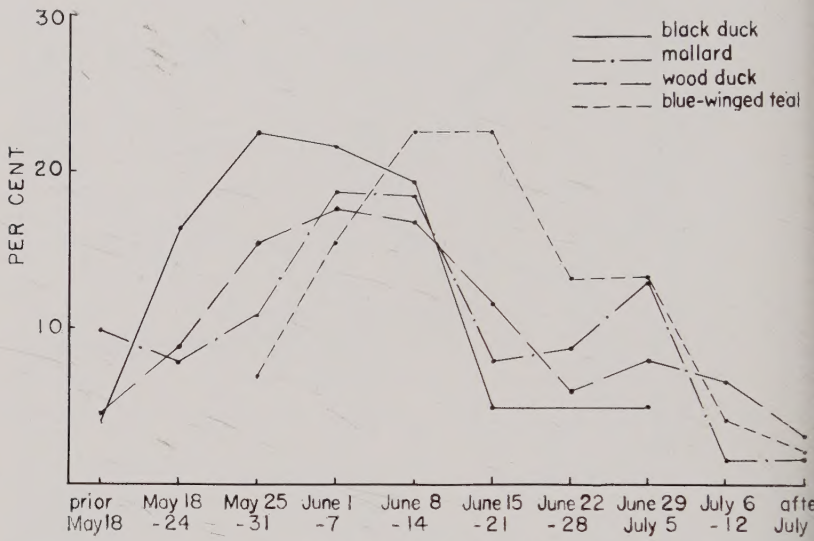

Figure 2. Distribution of calculated hatching dates of waterfowl broods observed on the Howland Island area in 1936, 1937, 1942, 1953, 1954 and 1955.

broods were present before June 1, and it was not until the third week in June that half had hatched. For all four species relatively few broods hatched after July 1.

Also, from 1953 to 1956, records for 24 broods of Canada geese were obtained. One hatched on April 29, 1953. Calculated hatching dates for the others indicated that several hatched during the first week of May, the majority from May 7 to 14.

ITHACA REGION

Surveys were made on water areas in the general vicinity of Ithaca in 1939, 1940, 1941, 1953, 1954 and 1955. Most of these were natural marshes, but some of those included during the last three years were man-made. The data (Table 2 and Figure 3) indicate a strong similarity between the hatching pattern there and that at Howland Island. For the black duck the patterns were almost identical. Mallards, however, apparently started nesting later, but, by the first week of June, the proportion of the total hatch was as high as that at Howland Island. The same was true for wood ducks, except that it was not until the third week of June that the proportion of nests hatched was comparable to that at Howland Island. Blue-winged teal were present only as an occasional pair on this group of water areas.

OTHER AREAS

In 1954, 1955 and 1956 flightless young waterfowl were trapped for

Broods observed	Calculated distribution by period										Total
	Prior May 18	May 18–24	May 25–31	June 1–7	June 8–14	June 15–21	June 22–28	June 29–July 5	July 6–12	After July 12	
Black duck											
Number	4	17	12	14	14	6	5	2	1	....	75
Percentage											
By period	5.3	22.7	16.0	18.7	18.7	8.0	6.6	2.7	1.3	....	100.0
Cumulative	5.3	28.0	44.0	62.7	81.4	89.4	96.0	98.7	100.0	....	100.0
Mallard											
Number	1	12	28	30	28	22	11	12	2	2	148
Percentage											
By period	0.7	8.1	18.9	20.2	18.9	14.9	7.4	8.1	1.4	1.4	100.0
Cumulative	0.7	8.8	27.7	47.9	66.8	81.7	89.1	97.2	98.6	100.0	100.0
Wood duck											
Number	3	9	21	52	47	44	23	19	10	4	232
Percentage											
By period	1.3	3.9	9.1	22.4	20.2	19.0	9.9	8.2	4.3	1.7	100.0
Cumulative	1.3	5.2	14.3	36.7	56.9	75.9	85.8	94.0	98.3	100.0	100.0

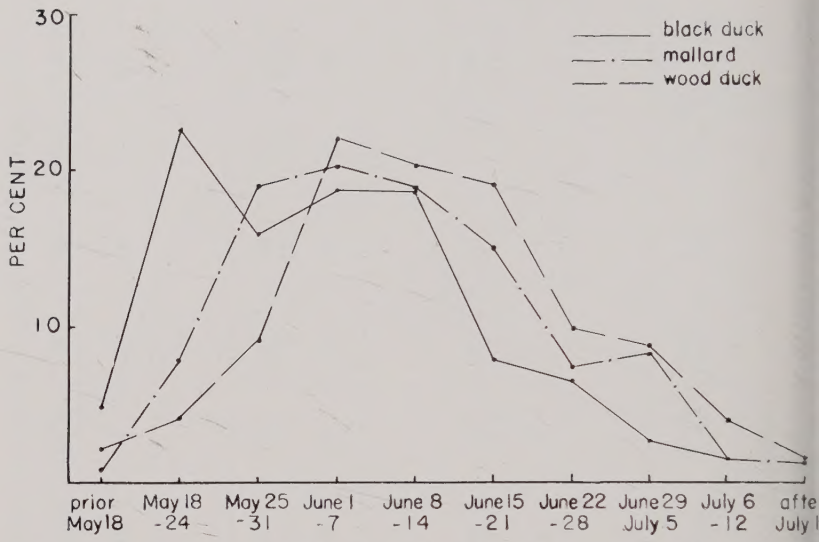

Figure 3. Distribution of calculated hatching dates of waterfowl broods observed the Ithaca region in 1939, 1940, 1941, 1953, 1954 and 1955.

banding purposes on wildlife marshes in Orleans and Genesee Countie A total of 312 ducklings, which appeared to represent 101 broods, wer examined. They were assigned to age classes based on plumage develop ment. The calculated hatching dates are given in Table 3. Except po sibly for the wood duck, the number of records for any species was to few to demonstrate a hatching pattern. The usefulness of these data lie we believe, in the fact that their distribution agrees well with that of th records based solely on observation from a distance.

OTHER RECORDS

Other, less intensive surveys also provided information on waterfow hatching dates in New York.

Game Management Regions

From 1953 to 1957 observations were recorded by game managemen personnel throughout much of upstate New York. These observers ha had no special opportunity to become acquainted with known-age ducl lings, and they had a tendency to overestimate brood ages. Also, the surveys were made largely in late June and early July and afforded litt opportunity to record late broods. Consequently, these data are le representative of actual hatching dates than are the records of researc personnel. They do indicate peak periods of hatch, however, and the may be used to show regional variations in such peaks.

Records from the Allegany, South Central and Catskill distric showed no differences in hatching dates and were combined under th

ABLE 3. CALCULATED HATCHING DATES OF WATERFOWL BROODS TRAPPED, WHILE STILL FLIGHTLESS, IN GENESEE AND ORLEANS COUNTIES IN 1954, 1955 AND 1956

Broods observed	Calculated distribution by period									Total
	Prior May 18	May 18–24	May 25–31	June 1–7	June 8–14	June 15–21	June 22–28	June 29–July 5	July 6–12	
Black duck										
umber										
1954	...	1	1	...	...	...	...	...	...	2
1955	1	...	1	...	...	...	...	...	...	2
1956	...	...	...	...	2	1	...	...	...	3
Total	1	1	2	...	2	1	...	...	...	7
rcentage										
By period	14.3	14.3	28.5	...	28.5	14.4	...	...	...	100.0
Cumulative	14.3	28.6	57.1	57.1	85.6	100.0	...	...	...	100.0
Mallard										
umber										
1954	...	...	1	1	1	1	...	...	1	5
1955	1	...	1	3	...	2	...	2	...	9
1956	...	...	1	1	1	...	1	2	1	7
Total	1	...	3	5	2	3	1	4	2	21
rcentage										
By period	4.8	...	14.3	23.8	9.5	14.3	4.8	19.0	9.5	100.0
Cumulative	4.8	4.8	19.1	42.9	52.4	66.7	71.5	90.5	100.0	100.0
Wood duck										
umber										
1954	...	1	2	4	4	3	1	1	1	17
1955	1	2	3	7	2	4	4	2	...	25
1956	...	1	2	3	2	4	3	...	...	15
Total	1	4	7	14	8	11	8	3	1	57
rcentage										
By period	1.8	7.0	12.3	24.6	14.0	19.2	14.0	5.3	1.8	100.0
Cumulative	1.8	8.8	21.1	45.7	59.7	78.9	92.9	98.2	100.0	100.0
Blue-winged teal										
umber										
1954	...	...	...	1	2	2	...	1	...	6
1955	...	1	...	3	1	1	...	...	...	6
1956	...	...	...	...	...	...	2	1	1	4
Total	...	1	...	4	3	3	2	2	1	16
rcentage										
By period	...	6.3	...	25.0	18.7	18.7	12.5	12.5	6.3	100.0
Cumulative	...	6.3	6.3	31.3	50.0	68.7	81.2	93.7	100.0	100.0

TABLE 4. CALCULATED HATCHING DATES OF BLACK DUCK BROODS OBSERVED DURING GAME MANAGEMENT OPERATIONS FROM 1953 TO 1957

Broods observed	Calculated distribution by period										Total
	Prior May 18	May 18–24	May 25–31	June 1–7	June 8–14	June 15–21	June 22–28	June 29–July 5	July 6–12	After July 12	
Southern Tier											
Number	5	9	6	9	10	4	4	3	2	....	52
Percentage											
By period	9.6	17.3	11.5	17.3	19.2	7.7	7.7	5.9	3.8	....	100.0
Cumulative	9.6	26.9	38.4	55.7	74.9	82.6	90.3	96.2	100.0	....	100.0
Erie-Ontario Lowland											
Number	19	14	15	5	3	12	12	2	1	1	74
Percentage											
By period	25.7	18.8	20.3	6.7	4.1	16.2	2.7	2.7	1.4	1.4	100.0
Cumulative	25.7	44.5	64.8	71.5	75.6	91.8	94.5	97.2	98.6	100.0	100.0
Ontario-St. Lawrence											
Number	1	3	5	5	....	....	1	....	....	....	15
Percentage											
By period	6.7	20.0	33.3	33.3	....	....	6.7	....	....	....	100.0
Cumulative	6.7	26.7	60.0	93.3	93.3	93.3	100.0	....	....	....	100.0

Number	8	9	13	12	4	3	2	....	....	....	51
Percentage											
By period	15.7	17.6	25.6	23.5	7.8	5.9	3.9	....	....	....	100.0
Cumulative	15.7	33.3	58.9	82.4	90.2	96.1	100.0	....	....	....	100.0

Lower Hudson Valley

Number	8	5	4	1	....	4	....	1	....	....	23
Percentage											
By period	34.8	21.8	17.4	4.3	....	17.4	....	4.3	....	....	100.0
Cumulative	34.8	56.6	74.0	78.3	....	95.7	95.7	100.0	....	....	100.0

Total

Number	41	40	43	32	17	23	9	6	3	1	215
Percentage											
By period	19.1	18.6	20.0	14.9	7.9	10.7	4.1	2.8	1.4	0.5	100.0
Cumulative	19.1	37.7	57.7	72.6	80.5	91.2	95.3	98.1	99.5	100.0	100.0

Table 5. Calculated Hatching Dates of Mallard Broods Observed during Game Management Operations from 1953 to 1957

Broods observed	Calculated distribution by period										Total
	Prior May 18	May 18–24	May 25–31	June 1–7	June 8–14	June 15–21	June 22–28	June 29–July 5	July 6–12	After July 12	
Southern Tier											
Number	2	19	12	10	4	9	1	5	1	....	63
Percentage											
By period	3.2	30.2	19.0	15.9	6.3	14.3	1.6	7.9	1.6	....	100.0
Cumulative	3.2	33.4	52.4	68.3	74.6	88.9	90.5	98.4	100.0	....	100.0
Erie-Ontario Lowland											
Number	28	27	23	26	17	12	6	5	5	1	150
Percentage											
By period	18.7	18.0	15.3	17.4	11.3	8.0	4.0	3.3	3.3	0.7	100.0
Cumulative	18.7	36.7	52.0	69.4	80.7	88.7	92.7	96.0	99.3	100.0	100.0
Ontario-St. Lawrence											
Number	1	....	2	1	....	1	....	....	....	....	5
Percentage											
By period	20.0	....	40.0	20.0	....	20.0	....	....	....	....	100.0
Cumulative	20.0	20.0	60.0	80.0	80.0	100.0	....	....	....	....	100.0

Middle Hudson Valley

Number	5	1	2	2	3	3	3	1	1	....	21
Percentage											
By period	23.7	4.8	9.5	9.5	14.3	14.3	14.3	4.8	4.8	....	100.0
Cumulative	23.7	28.5	38.0	47.5	61.8	76.1	90.4	95.2	100.0	....	100.0

Lower Hudson Valley

Number	6	5	2	2	....	2	....	....	....	....	17
Percentage											
By period	35.2	29.4	11.8	11.8	....	11.8	....	....	....	....	100.0
Cumulative	35.2	64.6	76.4	88.2	88.2	100.0	....	....	....	....	100.0

Total

Number	42	52	41	41	24	27	10	11	7	1	256
Percentage											
By period	16.4	20.4	16.0	16.0	9.4	10.5	3.9	4.3	2.7	0.4	100.0
Cumulative	16.4	36.8	52.8	68.8	78.2	88.7	92.6	96.9	99.6	100.0	100.0

Table 6. Calculated Hatching Dates of Wood Duck Broods Observed during Game Management Operations from 1953 to 1957

Broods observed	Calculated distribution by period										Total
	Prior May 18	May 18–24	May 25–31	June 1–7	June 8–14	June 15–21	June 22–28	June 29–July 5	July 6–12	After July 12	
Southern Tier											
Number	....	8	9	15	18	13	4	5	2	2	76
Percentage											
By period	....	10.5	11.8	19.7	23.8	17.1	5.3	6.6	2.6	2.6	100.0
Cumulative	....	10.5	22.3	42.0	65.8	82.9	88.2	94.8	97.4	100.0	100.0
Erie-Ontario Lowland											
Number	8	18	30	29	32	19	10	7	3	3	159
Percentage											
By period	5.0	11.3	18.9	18.2	20.2	11.9	6.3	4.4	1.9	1.9	100.0
Cumulative	5.0	16.3	35.2	53.4	73.6	85.5	91.8	96.2	98.1	100.0	100.0
Ontario-St. Lawrence											
Number	....	1	5	4	1	4	1	....	....	....	16
Percentage											
By period	....	6.3	31.1	25.0	6.3	25.0	6.3	....	....	....	100.0
Cumulative	....	6.3	37.4	62.4	68.7	93.7	100.0	....	....	....	100.0

Middle Hudson Valley

Number	2	3	5	8	1	4	2	2	....	....	27
Percentage											
By period	7.4	11.1	18.5	29.7	3.7	14.8	7.4	7.4	....	....	100.0
Cumulative	7.4	18.5	37.0	66.7	70.4	85.2	92.6	100.0	....	....	100.0

Lower Hudson Valley

Number	8	2	2	5	4	1	1	....	....	....	23
Percentage											
By period	34.8	8.7	8.7	21.8	17.4	4.3	4.3	....	....	....	100.0
Cumulative	34.8	43.5	52.2	74.0	91.4	95.7	100.0	....	....	....	100.0

Total

Number	18	32	51	61	56	41	18	14	5	5	301
Percentage											
By period	6.0	10.6	16.9	20.2	18.6	13.6	6.0	4.7	1.7	1.7	100.0
Cumulative	6.0	16.6	33.5	53.7	72.3	85.9	91.9	96.6	98.3	100.0	100.0

heading Southern Tier, except for those from the Hudson Valley. Likewise, records for the Lake Plains and North Central districts were grouped under the heading Erie-Ontario Lowland.

The data are given in Tables 4, 5 and 6 for the black duck, mallard and wood duck, respectively. They indicate that, for all three species, nesting began earlier in the lower Hudson Valley than in any other part of upstate New York and that a high proportion of the broods hatched there before June 1. The main hatching period was a little later in the Erie-Ontario Lowland, followed by those in the middle Hudson Valley, the Southern Tier and the Ontario-St. Lawrence area.

Long Island

No specific surveys for waterfowl broods were made on Long Island, but two activities provided information indicative of hatching dates. During the last week of May each year from 1935 to 1939 a black duck nest survey was conducted on Fire Island; 30 nests were found, all between May 23 and 29. Only one clutch was found that had already hatched (May 24, 1939). All the other nests contained apparently complete clutches in advanced stages of incubation, suggesting that in this area there was relatively little spread in the dates when the ducks started nesting. It seemed probable that all these clutches would have hatched by the end of the first week of June.

The other source of data was the investigation of the status of waterfowl and their habitat on Long Island in 1950 (Foley, 1952). Records for the seven black duck broods observed indicated May 5 as the earliest hatching date and June 29 as the latest; most of them hatched in mid-June. There were 35 mallard broods observed, and their calculated hatching dates ranged from May 5 to July 29 with a main peak occurring in early May; a minor peak from late nesting or renesting appeared in early June. Two wood duck broods were judged to have hatched about June 20, and 19 gadwall broods between June 16 and July 7. Five Canada goose broods apparently hatched between May 1 and 18, while the development of 16 mute swan broods indicated a primary peak about May 7 to 15 and a secondary one in late June.

Adirondack Region

Each summer from 1955 to 1959 project personnel made brief surveys of the occurrence of waterfowl on a number of water areas in the central Adirondacks. The work was done during the last half of July. Broods encountered were chiefly those of the ring-necked duck and black duck (Table 7). The few wood duck broods observed were judged to have hatched about June 20 to 25. Two American goldeneye broods appeared to have hatched about July 1.

TABLE 7. CALCULATED HATCHING DATES OF RING-NECKED DUCK AND BLACK DUCK BROODS OBSERVED IN THE ADIRONDACK REGION FROM 1955 TO 1959

Broods observed	Calculated distribution by period									
	May 18–24	May 25–31	June 1–7	June 8–14	June 15–21	June 22–28	June 29–July 5	July 6–12	After July 12	Total
Ring-necked duck										
Number										
1955	...	...	...	...	...	3	13	3	...	19
1956	...	...	...	...	...	1	...	1	14	16
1957	...	...	...	...	...	5	1	2	...	8
1958	...	...	...	...	...	2	2	5	2	11
1959	...	...	...	1	...	4	11	5	2	23
Total	...	...	...	1	...	15	27	16	18	77
Percentage										
By period				1.3	...	19.5	35.1	20.7	23.4	100.0
Cumulative	...	...	...	1.3	...	20.8	55.9	76.6	100.0	100.0
Black duck										
Number	1	3	16	9	3	3	1	1	1	38
Percentage										
By period	2.6	7.9	42.2	23.7	7.9	7.9	2.6	2.6	2.6	100.0
Cumulative	2.6	10.5	52.7	76.4	84.3	92.2	94.8	97.4	100.0	100.0

In New York the ring-necked duck has been found as a breeding pecies only in the Adirondack area where it appears to be a late nester. The records indicated a hatching period extending from about June 22 nto mid-July; only one earlier brood was noted. This pattern agrees ith the findings of Mendall (1958) in Maine. Data for the individual ears indicated that the great majority of clutches in any given season atched at about the same time. The data also suggest that this species quite responsive to weather conditions; the peak of hatching was par-cularly late in 1956 when temperatures during May and early June ere below average.

Too few black duck broods were observed to show annual variations, ut the combined data for the four years illustrate that this species nested ter in the Adirondacks than elsewhere in the State. It was not until te June that the cumulative proportion of nests that had hatched became mparable to that for other parts of the State.

In the course of these surveys, 15 broods of the hooded merganser nd 11 of the American merganser were observed for which satisfactory ge estimates could be made. For both species, the records indicated a

wide spread in hatching dates from the third week in May to early July. The peak for the hooded merganser included the last week of May and the first week of June. That for the American merganser appeared to be a little later, probably in the second week of June. Only two broods of the red-breasted merganser were noted; one probably hatched about June 20 and the other about July 15.

EARLY HATCHING DATES

Too few known hatching dates were recorded to serve as a check against the calculated dates, but those that were fell within the general pattern shown in Tables 1 and 2. Several unusually early dates are of interest. The two earliest hatching dates known (to the authors) for wild ducks in New York both involved mallards. A brood was hatched April 24, 1957 at the Oak Orchard Game Management Area in Genesee County, and another on the Three Rivers Game Management Area in Onondaga County on April 27, 1953. The earliest such date for the black duck was May 2 (1941) on the Seneca River in Cayuga County. While estimated brood ages suggest earlier dates, the earliest known hatching date for the wood duck was May 14 (1954) at the Oak Orchard area; and that for the blue-winged teal was May 17 (1955) on the same area.

RENESTING AND LATE NESTING

Observations of both captive and wild ducks have shown that some individuals renest if their first nest is broken-up. Such renesting occurs chiefly when the first nest is broken-up during the laying period or the first half of the incubation period, rarely later. Data for the Howland Island area (Figure 2) demonstrate a late second peak in hatching dates which may represent renesting, especially with respect to the mallard. Projecting the decline following the first peak, one would expect to find few new broods by the week of June 22. In this instance, however, some 25 per cent of all the mallard broods hatched after this date. Assuming that a minimum of 5 weeks would be required for a mallard to renest and hatch a second clutch, these late broods could in part have been produced by hens whose first nests had been broken-up during the early stages of laying or incubation.

While the behavior of game farm ducks is not directly comparable to that of wild birds, egg collection records for mallard stock provide clues to egg laying distribution. Although scattered eggs may be picked up in early April, it was not until the third week in April, in most years at the Delmar Game Farm, that many of the females began laying. Peak laying usually occurred during the last week of April when the number of eggs collected daily often equalled half the number of penned females. During this first laying period individual females averaged about three eggs per week. Each year during early May (dates ranged from May 3 to 18 from 1936 through 1942) a lull in egg production occurred during which

the number of eggs in daily collections represented as few as 10 per cent of the females. This lull in production usually lasted upwards of a week, after which daily collections rose rapidly to a new peak and equally rapidly dropped off to another low. This second laying period lasted about 2 weeks, and the weekly production for individual females was somewhat more than three eggs.

Applying this game farm evidence to wild conditions, it appears that relatively few mallards would hatch before June 1 since 3½ weeks are required for incubation. The peak of hatching in most years would fall toward the end of the first week or in the second week of June. Broods from renesting attempts, if they were associated with the second laying period noted, would show a peak 3 to 4 weeks after the first hatching peak. This would be the last week in June or the first week in July which is in agreement with the data for wild mallards given in Table 1.

Observations during the mallard stocking studies of 1939 through 1943 indicated that the initial nesting time may be delayed due to variations in water levels and food supplies although too many variables entered here to define any pattern. In these instances temporarily flightless stock was involved that could not readily move to other areas. No definite delay in the start of nesting was observed among wild ducks except in the case of the ring-necked duck where it appeared to relate to adverse spring weather and ice conditions.

SECOND BROODS

Two instances of mallards bringing off a second brood after hatching their first clutch have been observed. In 1939 on the Michigan Hollow Beaver Pond in Tompkins County a released mallard nested successfully and her brood hatched on June 14 or 15. This bird sat quite tight on her nest so that she was picked up and her band read without causing her to leave the nest. Two or three days after the eggs hatched this bird deserted her brood, took off on courtship flight with a still full-plumaged drake, and by July 6 had started a new clutch on the original nest site. In late July this bird was again picked off the nest and the band identified. A subsequent check in August indicated the nest had hatched, but the duck and her brood were not located. As an interesting sidelight, two young mallard ducklings were observed on June 18, and once more in late June, with a wood duck brood near the point where the mallard had hatched and deserted her first brood.

The second instance was observed at Howland Island in 1960 when a mallard duck with a distinctive color pattern hatched a brood in late May. No definite observations were made on the fate of this first brood but what appeared to be the same female was observed with a newly-hatched brood in August.

One similar instance of the production of a second brood was ascribed to a black duck in 1951 on Long Island. Mr. Siegfried Peters of the

Baiting Hollow Boy Scout Camp saw the first brood of four ducklings on April 8, after he had captured the hen on the nest and banded her with a celluloid band. The fate of this brood is unknown. On September 8, he saw the same bird with a brood about a week old, identifying her by means of the celluloid band. A new nest site must have been used, since checking in the vicinity of the old one from time to time had revealed no nest or hen. It is possible of course that this bird may have adopted a less maternal duck's brood, although Mr. Peters, in his knowledge of the inhabitants of the marsh, thought this unlikely.

ANNUAL VARIATIONS IN HATCHING DATES

Each year the field biologist forms an opinion as to whether it is an early, average or late breeding season. When one returns to the brood records, however, these opinions are difficult to substantiate. No data collected in this study showed variations that could be considered real annual differences in hatching dates except possibly those for the ring-necked duck. Most individuals of this species seemed to have started nesting at very nearly the same time during a given season, and even the small number of observations recorded showed marked differences between certain years. For species where nearly equal numbers of broods may be hatching each week over a 3-week period, a very large amount of data would be required to show annual variations. The next best answer is to be found by drawing again on game farm records. As was discussed earlier, the number of eggs collected from game farm birds declined each year in early to mid-May; this was believed to represent the end of the first laying period. From 1936 through 1942 the date of this low point in egg production by mallards varied from May 3 to May 18 (yearly distribution May 7, 3, 6, 12, 18, 3 and 8, respectively.) These data indicate that a variation of as much as two weeks may be expected in the peak of hatching. But, while it may vary a week either way from the average, such a variation would be difficult to demonstrate in rough field studies.

DISCUSSION

In theory, since waterfowl, like other birds, come into the laying period largely in response to the increasing hours of daylight, a normal bell-shaped curve should represent the distribution of hatching dates. The leading edge of such a curve would represent early nesters and the trailing edge late nesters and birds that had been retarded for one reason or another. Upwards of half the breeding females may have had their first nests destroyed, however. If a second laying period occurs in the wild as it appears to on game farms, then there should be a second, low peak for renesting ducks. Only for the mallards, and possibly wood ducks, on the Howland Island area was such a two-peaked curve evident (Figure 2). There are hints of this phenomenon in the data in Table 3

as well as in other records from the Ontario-St. Lawrence region (Kutz *et al.*, 1948) for blue-winged teal and black ducks and from the Hudson Valley (Foley, 1951) for wood ducks. The lack of two peaks for other species or other sections of the State may be a reflection of too few data. Or the first laying period may have been more prolonged so that some late nests were still hatching when early renests began to hatch. Possibly such species as the black duck are less prone to renest. Whatever the answer may be, the available data are inadequate to show it.

The calculated hatching dates presented here demonstrate that, of the three most widely distributed species in New York, the black duck is the earliest nester, followed by the mallard and then the wood duck. Where the blue-winged teal occurs, the peak of hatching appears to be 2 to 3 weeks later than that of the black duck and a week behind that of the mallard and wood duck. While there is little difference between the peaks for mallards and wood ducks, the latter has more late nesters. As a result, the cumulative percentage for wood duck nests hatched lags until late June when approximately equal proportions of the nests of all the species have hatched. While the term "peak of hatching" has been used, actually there usually seems to be a 2- to 4-week period when nearly equal numbers of broods are hatched each week. For those regions of the State where spring comes later, the plateau-like portion of the curve would be foreshortened.

In a State the size of New York with such widely varying topography and climate, regional differences in hatching dates occur. While Long Island is the most southern section of the State, the data indicate that hatching dates there are slightly later than those in the lower Hudson Valley. Possibly this reflects a tempering effect from the maritime climate of Long Island, or the samples for both areas may have been too few. The Southern Tier area bordering on Pennsylvania has a later average hatching period than the Erie-Ontario Lowland. Here it appears that higher elevations and later thawing in the spring counters the more southern latitude. On some of the rivers in the Adirondacks, such as the Saranac downstream from Trudeau, the marshes are opened early by spring high water. Early nesting by black ducks there is common, with broods that can match ages with those of the Erie-Ontario area; yet the birds using the normally late-opening marshes in the Adirondack region have a late hatching period. These variations complicate efforts to establish any general sampling system involving only one or two surveys, such as aerial counts, to measure annual production.

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THE FLUKE POPULATION OF GREAT SOUTH BAY IN RELATION TO THE SPORT FISHERY[1]

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ABSTRACT

To investigate the causes for a decline in recent years in late-season fishing success for fluke in Great South Bay, 5,845 fluke were tagged from 1956 to 1959. Tagging was done in Great South Bay and in ocean waters off Shinnecock Inlet and Fire Island Inlet. Returns showed little movement of fluke out of the bay during summer, but they indicated heavy early-season fishing to be an important factor in the decline. In 1956 and 1959, when 25 to 30 per cent of the calculated population was taken by sport fishing during June and July, the catch declined sharply during August and September. In 1958, on the other hand, the early catch was only 14 per cent and that in August and September increased markedly.

Rates of exploitation of the fluke population by the sport fishery in Great South Bay each summer averaged about 20 per cent. Since the bay is the primary summer nursery ground for young fluke, such rates are considered to permit a low degree of escapement of young fish. At present, the sport fishery is to a large extent dependent upon the abundance of fluke 30.5 centimeters or less in length. Returns in years subsequent to the one in which fluke were tagged in Great South Bay indicated a strong tendency for the population to return to the bay itself after wintering elsewhere. For recoveries during the second and third summers, from 25 to 53 per cent were taken in Great South Bay and from 50 to 80 per cent in all the south-shore bays of Long Island. Estimates of survival from year to year indicate that the sport fishery, the winter trawl fishery and the summer commercial fishery are overexploiting the fluke population at the present time.

Management to stabilize the catch in Great South Bay throughout the summer seems feasible by limiting in some manner the early fishing pressure. There also appears to be a need for size or catch limits to permit greater escapement of small fluke.

In the early 1950's, many people interested in the sport fishery for fluke (*Paralichthys dentatus*) in Great South Bay expressed concern over decreased catches during the latter part of the summer. Late-season decreases had apparently not been experienced prior to 1950. For example, in 1938, studies showed that the catch per effort and the total catch of the sport fishery increased substantially in late summer (Neville *et al.*, 1939). Many felt that the decreased catches were due to overfishing. Others suggested that the habits of the fish had changed and that they left the bay in large numbers in late July rather than in September and October. To investigate the causes for these declining catches, a series of tagging operations was undertaken from 1956 to 1959.

Monthly catch statistics for fluke taken by sport fishermen in Great South Bay generally supported the reports of decreased catches as the summer season progressed (Table 1). In 1956, 1957 and 1959, the greatest numbers were taken in either June or July, after which the catch declined throughout the remainder of the summer. In 1958, however, the pattern was reversed. Monthly catches increased to 552,848 fluke in August; in September, 209,853 fish were caught. The increase during the late summer of 1958 paralleled the catch pattern in 1938 as described

[1] A contribution of Federal Aid in Fish and Wildlife Restoration Project F-15-R.

Table 1. Monthly Catch of Fluke by Sport Fishermen in Great South Bay, 1956–1959*

Month	1956	1957	1958	1959
June	602,802	398,000	319,138	608,425
July	758,269	247,999	426,491	554,067
August	278,066	117,677	552,848	279,815
September	144,792	27,122	209,853	96,245
Total	1,783,929	790,798	1,508,330	1,538,552

* After Briggs (1962).

by Neville *et al.* (1939). What is of more importance than this similarity, however, is the fact that the data for 1958 indicate that an above-average proportion of the catch by the sport fishery can be taken during the latter part of the summer without an apparent loss in the total fluke catch. In 1959, only 24 per cent were taken in August and September; in 1958, 51 per cent were caught during these months. Despite the late catch, the 1958 landing of 1,508,330 fluke almost equaled that of 1,538,552 for 1959.

METHODS

Fluke were tagged in Great South Bay in 1956, 1957, 1958 and 1959. Fluke were also tagged in the ocean off Shinnecock Inlet and Fire Island Inlet in 1957, and off Fire Island Inlet in 1958. The relationship of these localities is shown in Figure 1. The fish were taken by otter trawl

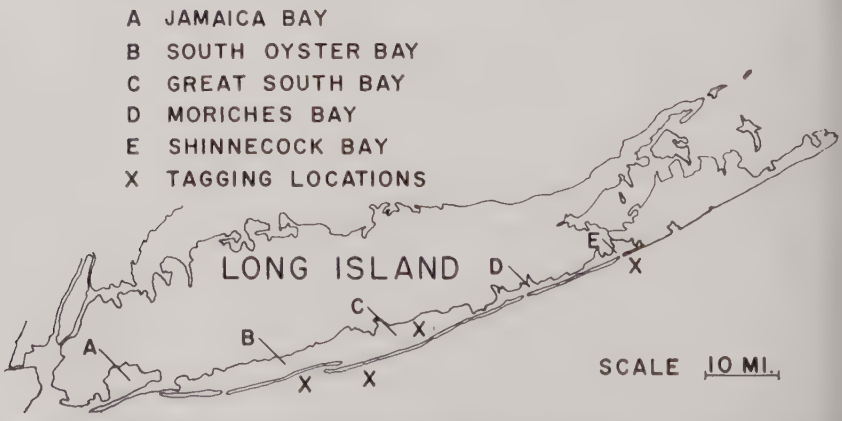

Figure 1. Map of Long Island showing locations where fluke were tagged and bays in which data were collected.

and held on board a research boat in a tank supplied with running sea water. They were measured and then tagged with serially numbered Petersen discs ½ inch in diameter. The discs were attached by means of nickel pins at a point in the musculature above the hump in the lateral line. The fish were released in the same locality in which captured.

Posters explaining the purposes of the tagging were distributed to rowboat stations, fishing tackle stores and docks from which charter, open and private boats sailed. A local radio station also described the studies. A reward of one dollar was offered for each return.

Information regarding location, method and date of recapture was generally included in each letter containing a tag return. When all information was not given, a form letter was sent requesting the data not originally supplied. Analysis of returns was correlated with statistics of the sport fishery (Briggs, 1962) and the commercial fishery.

RETURNS FROM FLUKE TAGGED IN GREAT SOUTH BAY

In Great South Bay 927, 1,000, 627, and 851 fluke, respectively, were tagged during June of the years 1956, 1957, 1958 and 1959. Differences in the size composition of these samples were greatest with respect to the proportion of fish 30.5 centimeters or less in total length (Figures 2–5). This proportion reflects the spawning success of the previous year upon the bay population as described by Poole (1961). In 1956 and 1959, fluke of this size comprised 45 per cent of the population. These fish were largely 1-year-olds, evidence of spawning success in 1955 and 1958. The data indicated spawning success in 1956 and 1957 was relatively low.

During Same Season as Tagged

Analysis of recaptures during the same season from fluke tagged in Great South Bay supports the view that there was little loss in abundance in the bay as a result of movement of the fish (Table 2). The highest proportion of recaptures in the ocean during the 4-year study occurred in 1958. Of these 21 returns which represented 12 per cent of the recaptures, 19 were taken during late September and October, a time when fluke characteristically start their migration to offshore wintering grounds. Recaptures from the ocean in the same season for fish tagged in 1956, 1957 and 1959 were recorded in most instances in September and October also. These returns indicate that large numbers of fluke do not leave the bay to enter ocean waters in midsummer. It is impossible to measure the proportion of the bay population which does so leave, because comparisons of fishing effort in the bay with that in the ocean cannot be made. The great percentage of returns, however, came from Great South Bay and within Fire Island Inlet. During this study, over 81 per cent of the recaptures each year during the 16-week period subsequent to tagging were recorded from these areas. Returns demonstrated a movement of

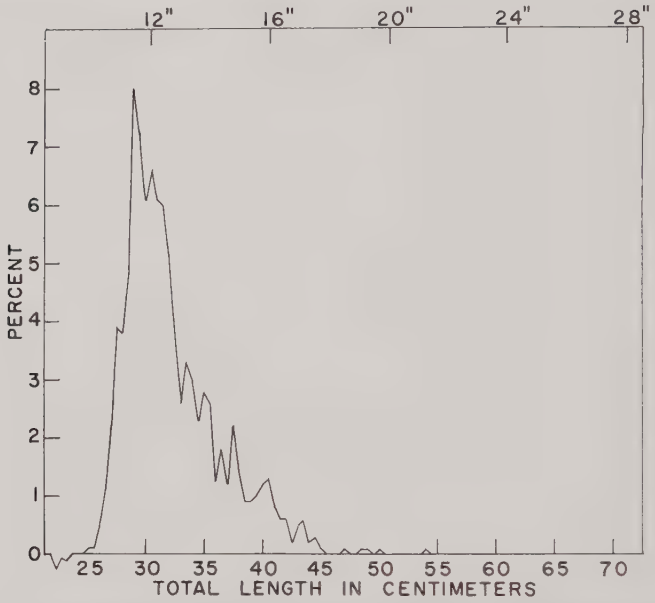

Figure 2. Length frequency of 927 fluke tagged during June 1956 in Great South Bay

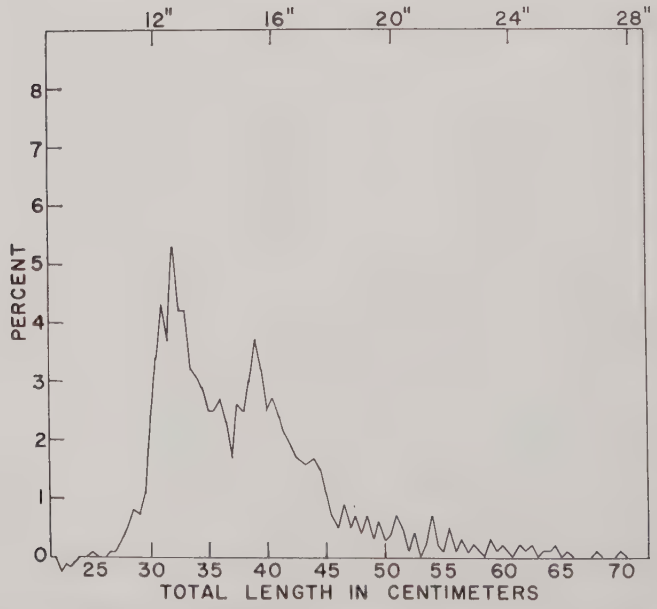

Figure 3. Length frequency of 1,000 fluke tagged during June 1957 in Great South Bay.

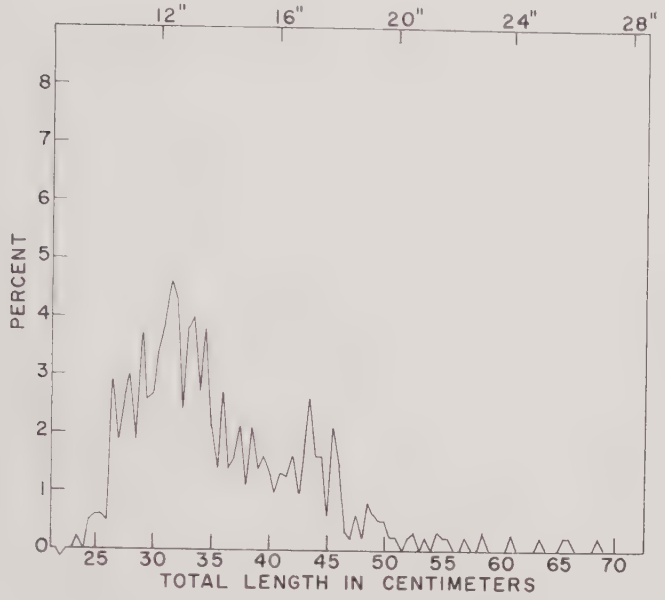

Figure 4. Length frequency of 627 fluke tagged during June 1958 in Great South Bay.

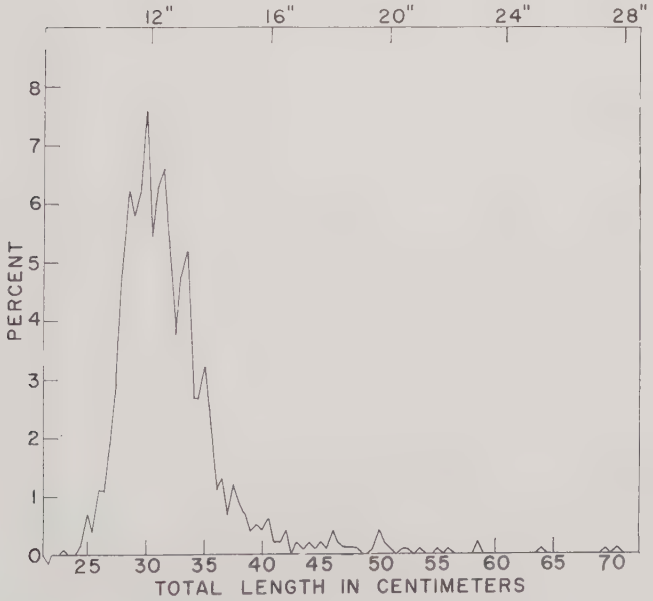

Figure 5. Length frequency of 851 fluke tagged during June 1959 in Great South Bay.

Table 2. Distribution, During 16-Week Period after Tagging, of Recaptures of Fluke Tagged in Great South Bay, 1956–1959*

Locality of recapture	1956		1957		1958		1959	
	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent
Great South Bay	92	39	13	15	40	23	81	35
Fire Island Inlet	116	49	62	71	103	59	136	59
Other south-shore bays	12	5	2	2	5	3	5	2
Ocean	13	5	5	6	21	12	10	4
Unknown	5	2	5	6	5	3	....	...
Total	238	100	87	100	174	100	232	100
Number of fish tagged§	920	xxx	991	xxx	624	xxx	837	xxx

* Includes recaptures by both sport and commercial fisheries.
§ Does not include fish tagged but recaptured while tagging was still in progress.

many fluke, that were present well up-bay in early summer, to the waters within Fire Island Inlet shortly after being tagged in June. The large degree of return from the inlet area was due to the concentration of fishing effort which occurred there each year.

Some movement of fluke from Great South Bay in early and mid-summer to other south-shore bays of Long Island occurred each year. Between 2 and 5 per cent of the recaptured fish were taken in South Oyster Bay, Moriches Bay or Shinnecock Bay. However, these percentages of recapture do not indicate extensive movement out of Great South Bay. Fishing pressure was heavy in each of the south-shore bays, and, if fluke had moved out of Great South Bay in great numbers, more recaptures of tagged fish elsewhere would have been reported. The most distant returns in the ocean during the same season for fish tagged in Great South Bay came from off Asbury Park, New Jersey, on July 20, 1956 and from Long Island Sound on August 3, 1959.

It is logical to conclude that, although some of the fluke present in early summer in Great South Bay move to adjacent bays and the ocean, the bulk of this population remains within the bay until mid-September. The decline in the fluke catch during late summer, which occurred in three of the four years of the study, cannot be attributed, therefore, to movement of large numbers of fluke to the adjacent bays or to the ocean.

Estimates of the fluke population in Great South Bay at the time of

tagging for each of the four years were calculated by using the following formula as given by Ricker (1958):

$$\hat{N} = \frac{M\,(C+1)}{R+1}$$

in which,

$\hat{N}$ = estimate of the size of the population at time of tagging
M = number of fish tagged
C = catch or sample taken for census
R = number of recaptured tagged fish in catch

These estimates demonstrate that there were approximately 5.5 million fluke in the bay in June of 1956, 1957 and 1958 (Table 3). In June of 1959, there were approximately 3.9 million fluke. It is significant that, despite the comparatively low sport catch of 392,798 fish in 1957, the

TABLE 3. ESTIMATES OF POPULATION SIZE AT TIME OF TAGGING AND OF RATES OF EXPLOITATION BY THE SPORT FISHERY FOR FLUKE IN GREAT SOUTH BAY, 1956–1959

Item*	1956	1957	1958	1959
Sport fishery catch (C)	1,181,127	392,798	1,189,192	931,127
Number fish tagged (M)	920	988§	624	831§
Number recaptured (R)	195	69	136	199
Population size ($\hat{N}$)	5,544,097	5,544,077	5,416,470	3,868,837
Rate of exploitation ($\hat{u}$)	21	7	22	24

* Catch and recapture data apply to period from July 1 to September 30 of same year in which fish were tagged.
§ Less than corresponding figures in Table 2 because a few fish were recaptured between the time tagging ended and July 1.

population estimate was approximately the same as those for 1956 and 1958; thus, the poor catch was not due to decreased population size.

Analysis of the length frequencies of the tagged fish which were caught by sport fishermen in the bay during the first summer subsequent to tagging revealed that the larger fish were as susceptible to hook and line fishing as the smaller fish. The length frequencies of tagged fish caught approximated those of the fish tagged during each of the four years (Figures 6, 7, 8, and 9). In 1957 and 1958, years in which larger fish were relatively more numerous, the larger tagged fish were caught more frequently than the smaller fish. Therefore, the low sport catch of 1957

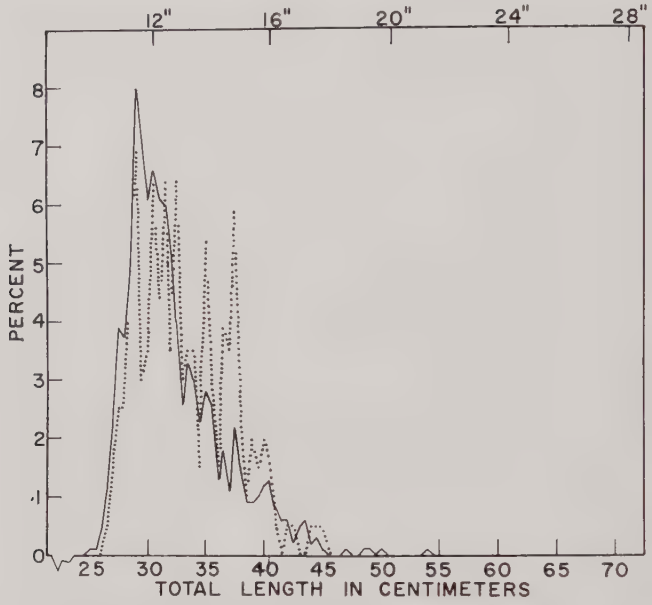

Figure 6. Length frequency of fluke tagged in 1956 (solid line) compared with that of 203 of same group caught during summer by hook and line in Great South Bay (dotted line).

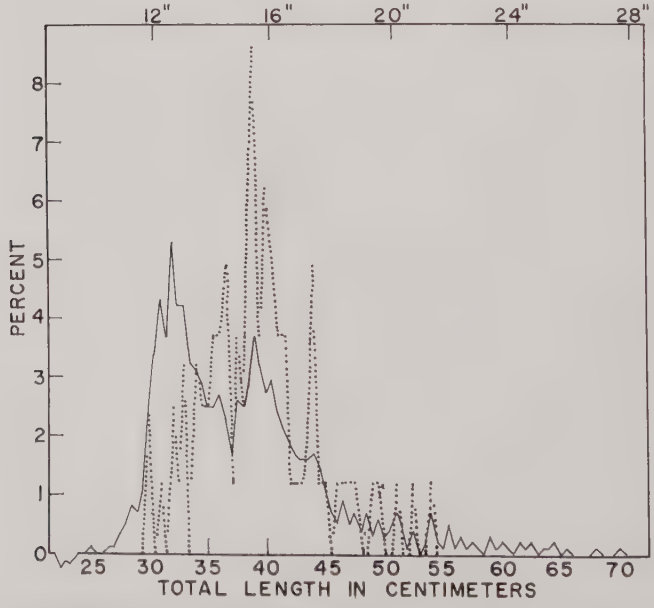

Figure 7. Length frequency of fluke tagged in 1957 (solid line) compared with that of 82 of same group caught during summer by hook and line in Great South Bay (dotted line).

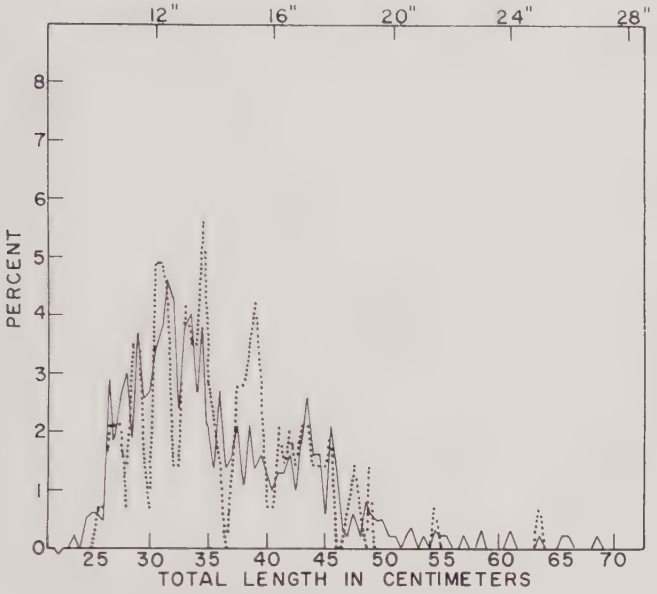

Figure 8. Length frequency of fluke tagged in 1958 (solid line) compared with that of 142 of same group caught during summer by hook and line in Great South Bay (dotted line).

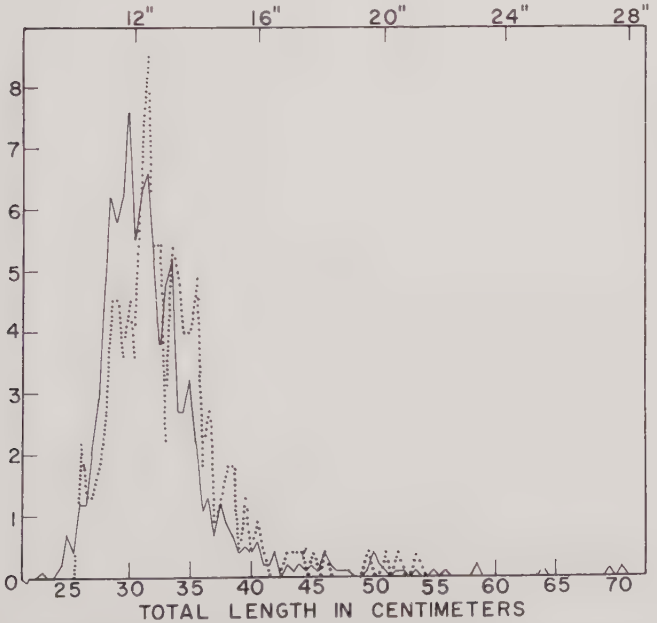

Figure 9. Length frequency of fluke tagged in 1959 (solid line) compared with that of 223 of same group caught during summer by hook and line in Great South Bay (dotted line).

cannot be attributed to a decrease in catchability of the larger fish. The low return of tagged fish in that year demonstrated a decreased catchability of all sizes of fluke by hook and line methods and indicates, together with the estimates of population size, that the environment of the fluke changed sufficiently to drastically lower the sport catch. This environmental change may have involved such physical factors as water temperature or salinity, or it may have been a difference in the abundance of associated species which compete with or are a food of the fluke.

The cause of the declining sport catch in the latter half of the summer during recent years can be explained to some extent by examination of the monthly tag returns and landings by sport fishermen in Great South Bay and Fire Island Inlet (Tables 1 and 4). In 1956, 1957 and 1959,

Table 4. Frequency of Recapture by Sport Fishing in Great South Bay and Fire Island Inlet during First Summer after Tagging for Fluke Tagged in Great South Bay, 1956–1959*

Month	1956		1957		1958		1959	
	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent
July	119	12.9	39	3.9	34	5.4	93	11.2
August	58	7.4	25	2.6	58	9.8	78	10.7
September	18	2.5	5	0.5	44	8.4	28	4.3
October	2	0.3	1	0.1	3	0.7	7	1.1
Total	197	21.4	70	7.1	139	22.3	206	24.8

* Percentages based on number of tagged fish estimated to have been present at the beginning of each month, or on July 1 in the case of total values.

the highest return of tagged fish occurred in July. During August the returns decreased, and in September they declined sharply. In each of these years the sport catch was at its highest in June and July. For these two months in 1956, it represented 25 per cent of the fish calculated to be present in the bay at the time of tagging; in 1959, 30 per cent. Such high fishing pressure apparently reduced the population levels to such an extent that reduced catches resulted in the latter part of the summers of 1956 and 1959.

It is difficult to explain the late summer decline in the success of sport fishing for fluke in 1957, since the rate of removal in June and July represented only 12 per cent of the bay population. The records indicate, however, that decreased catchability throughout the summer resulted in less fishing effort for fluke as the season progressed (Briggs, 1962).

During July of 1958 the rate of return was low; this was followed by increased returns in August and September. The sport fishery in June and July removed only 14 per cent of the calculated population at the time of tagging. In August, the catch increased, and during September it was the highest recorded for that month during the four years of the study. This increase following a low rate of removal in spring and early summer suggests that one cause of lower catches in the latter part of summer was the high proportion taken early in the season.

During Subsequent Summers

Recaptures of tagged fluke during summers subsequent to the year in which they were released indicated that there was a strong tendency for fluke which spent the summer in Great South Bay to return for the following two summers (Table 5). For example, between 25 and 53 per cent of the summer returns in these two years were recaptured within the bay. It is also noteworthy that in these two years from 50 to 80 per cent of all summer returns were recaptured in Great South Bay and other bays on Long Island's south shore. After this, the population apparently contributed little to the bay fisheries and, for that matter, little to the fisheries of other regions. During the third summer, dispersion and exploitation was such that, of 927 fluke tagged and released in 1956, only three returns were recorded: one from Shinnecock Bay and two from waters between Montauk Point and Massachusetts. Similarly, of 1,000 fluke tagged in 1957, only two returns were recorded in the summer of 1960: one from the bay and one from the ocean off the south shore. The degree of return to Great South Bay and other bays on the south shore of Long Island was great enough to suggest that management of the resource by means of season, size or catch limitations would not result in a large loss to the sport fishery.

In general, for fluke tagged in Great South Bay, dispersion in subsequent summers was in an easterly direction (Figures 10, 11, 12 and 13). Recaptures which demonstrated this dispersion were made most frequently in Long Island Sound, off Montauk Point, off Block Island, and in Narragansett Bay and Buzzards Bay. A few returns were from Chesapeake Bay and from Delaware and New Jersey waters. Returns from only one group demonstrated a marked dispersion westward to New Jersey (Figure 12). Since sport fishing for fluke in New Jersey is relatively intense, and since so few returns were recorded from that state's waters, there is good indication that either separate stocks exist to some degree or dispersion of a common stock is sufficiently great to give the appearance of two separate stocks.

During Winter

The distribution of returns obtained by trawling during the winter

Table 5. Frequency of Recapture During Successive Summers (May 1 to October 31) for Fluke Tagged in Great South Bay, 1956–1960

Locality of capture	1956		1957		1958		1959		1960	
	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent
Fluke tagged in 1956										
Great South Bay	208	88	19	25	6	43	...	..	...	..
Other south-shore bays	12	5	30	40	1	7	1	33	1	100
Ocean, New York City to Montauk	13	5	5	7	1	7	...	..	...	..
Long Island Sound	...	..	3	4	...	..	...	..	...	..
Ocean and bays										
Montauk to Mass.	...	..	14	18	4	29	2	67	...	..
New Jer. to Chesapeake	...	..	1	1	1	7	...	..	...	..
Unknown	5	2	4	5	1	7	...	..	...	..
Total	238	100	76	100	14	100	3	100	1	100
Fluke tagged in 1957										
Great South Bay	...	..	75	86	31	53	10	45	1	100
Other south-shore bays	...	..	2	2	16	27	4	18	...	..
Ocean, New York City to Montauk	...	..	5	6	5	8	4	18	1	100
Long Island Sound	...	..	...	..	...	..	1	5	...	..
Ocean and bays										
Montauk to Mass.	...	..	...	..	1	2	2	9	...	..
New Jer. to Chesapeake	...	..	...	..	3	5	1	5	...	..
Unknown	...	..	5	6	3	5	...	..	...	..
Total	...	..	87	100	59	100	22	100	2	100
Fluke tagged in 1958										
Great South Bay	...	..	...	..	143	82	29	45	3	38
Other south-shore bays	...	..	...	..	5	3	15	23	3	38
Ocean, New York City to Montauk	...	..	...	..	21	12	8	13	...	..
Long Island Sound	...	..	...	..	...	..	...	..	...	..
Ocean and bays										
Montauk to Mass.	...	..	...	..	...	..	4	6	...	..
New Jer. to Chesapeake	...	..	...	..	...	..	8	13	1	12
Unknown	...	..	...	..	5	3	...	..	1	12
Total	...	..	...	..	174	100	64	100	8	100
Fluke tagged in 1959										
Great South Bay	...	..	...	..	...	..	217	94	19	34
Other south-shore bays	...	..	...	..	...	..	5	2	25	44
Ocean, New York City to Montauk	...	..	...	..	...	..	7		2	4
Long Island Sound	...	..	...	..	...	..	1	4	3	5
Ocean and bays										
Montauk to Mass.	...	..	...	..	...	..	2		4	7
New Jer. to Chesapeake	...	..	...	..	...	..	...	..	2	4
Unknown	...	..	...	..	...	..	...	..	1	2
Total	..	..	...	..	..	..	232	100	56	100

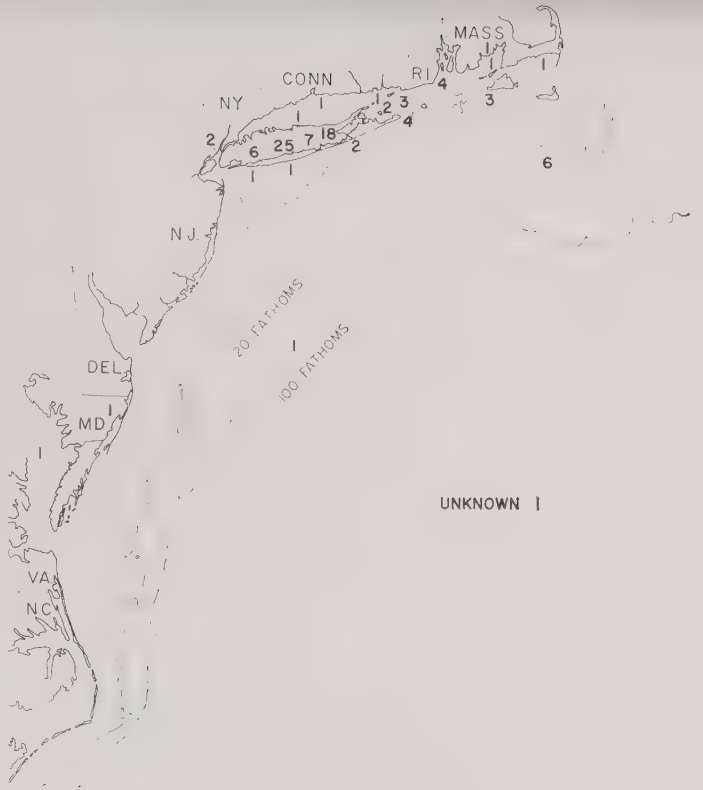

Figure 10. Distribution of recaptures during summer from 1957 to 1960 for fluke tagged in Great South Bay in 1956.

Figure 11. Distribution of recaptures during summer from 1958 to 1960 for fluke tagged in Great South Bay in 1957.

Figure 12. Distribution of recaptures during the summers of 1959 and 1960 for fluke tagged in Great South Bay in 1958.

Figure 13. Distribution of recaptures during the summer of 1960 for fluke tagged in Great South Bay in 1959.

was not markedly different for fluke tagged during individual years. For this reason all such returns were combined and plotted (Figure 14). Recaptures were generally concentrated near the 100-fathom contour. Relatively few were in waters as shallow as 20 fathoms. Returns were most frequent from an area from off the Delaware coast to Oceanographer Canyon southeast of Cape Cod; in most years they centered about the Hudson Canyon. However, recaptures of fluke tagged in 1956 were largely from the Hydrographer-Oceanographer Canyon area. Recaptures southeast of Cape Cod in 20 to 100 fathoms of water extended the reported winter trawl range of the fluke eastward from the vicinity of Montauk Point. Westman (1946) described the winter trawl fishery for fluke as occurring from New York to Virginia. The recaptures by winter trawling off Cape Cod reflect the recent development of an important fishery in that area.

In the late 1930's and early 1940's, the winter fishery for fluke operated primarily off the Middle Atlantic States and Virginia. In subsequent years the winter fishery off Cape Cod gradually developed. Landings from January through April at New Bedford (Mass.) increased and in 1959 amounted to 2,346,235 pounds of fluke, representing 62 per cent of the annual catch at that port (Table 6). This fishery has expanded to such an extent that generally half of the entire Massachusetts catch has occurred in the winter period since 1949.

Development of this fishery has placed additional pressure on the fluke resource and has increased the almost year-around vulnerability of

TABLE 6. COMMERCIAL LANDINGS (IN POUNDS) OF FLUKE AT NEW BEDFORD, MASSACHUSETTS, 1942–1959*

Year	January through April	Annual
1942	57	157,056
1943	225	71,250
1944	362,962	553,941
1945	1,016,811	1,527,294
1946	614,476	1,331,005
1947	163,207	1,123,818
1948	§	2,035,792
1949	867,387	1,430,376
1950	1,057,165	2,478,136
1951	1,267,930	2,938,816
1952	2,259,320	3,556,380
1953	1,731,081	2,913,431
1954	1,487,550	2,821,265
1955	3,195,200	4,653,145
1956	3,714,147	4,593,632
1957	2,741,025	5,134,169
1958	2,305,225	3,593,683
1959	2,346,235	3,779,917

* Data from U. S. Fish and Wildlife Service (1942–1959).
§ Not available.

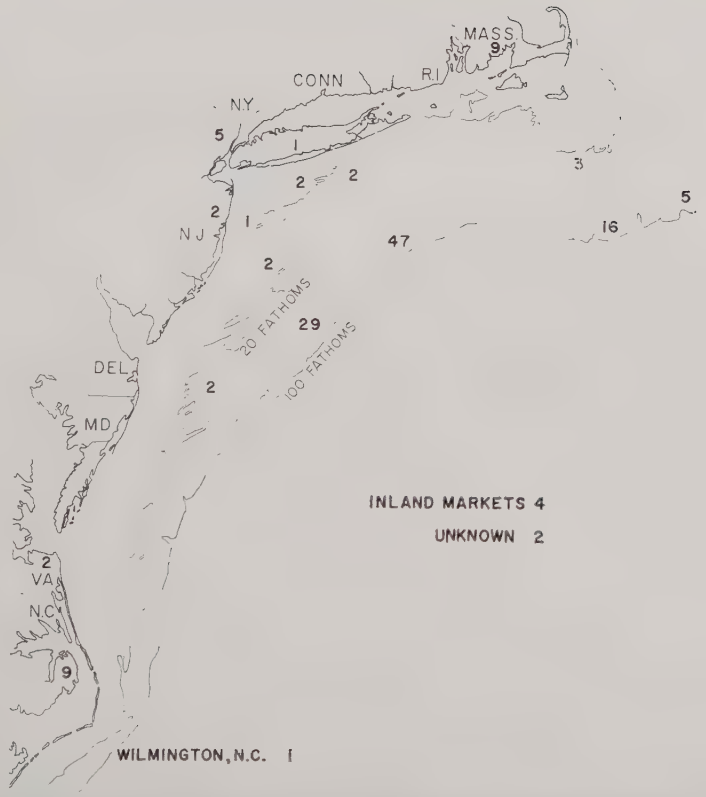

Figure 14. Distribution of recaptures during winter for fluke tagged in Great South Bay from 1956 to 1959.

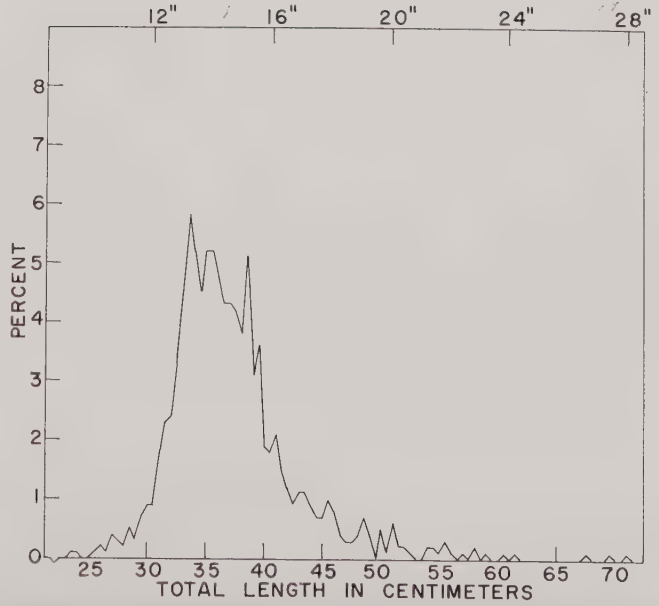

Figure 15. Length frequency of 998 fluke tagged during May 1957 in the ocean east of Shinnecock Inlet.

TABLE 7. ANNUAL COMMERCIAL LANDINGS (IN POUNDS) OF FLUKE FOR NEW ENGLAND AND MIDDLE ATLANTIC STATES, 1939–1959*

Year	Massachusetts	Rhode Island	Connecticut	New York	New Jersey	Delaware	Total
1939	1,399,800	211,100	248,100	2,666,100	2,604,000	11,300	7,140,400
1940	2,847,400	258,300	148,700	1,814,400	3,554,300	3,000	8,626,100
1942	192,900	234,500	125,500	1,286,300	986,800	1,600	2,827,600
1943	121,500	202,300	219,800	1,606,500	2,223,700	10,700	4,384,500
1944	718,800	413,900	436,800	2,150,700	3,159,100	8,000	6,887,300
1945	1,730,100	466,600	269,500	3,182,100	3,310,000	21,700	8,980,000
1946	1,579,000	625,300	477,700	3,494,100	§	§	§
1947	1,466,900	332,800	813,100	2,695,300	2,301,900	46,300	7,656,300
1949	1,786,700	469,600	371,700	3,560,000	3,024,500	8,300	9,220,800
1950	3,613,800	1,035,900	269,700	3,838,000	2,514,500	24,600	11,296,500
1951	4,506,000	1,188,700	440,500	2,635,600	2,864,500	19,800	11,655,100
1952	4,897,500	1,336,200	627,000	3,680,300	4,721,300	69,200	15,331,500
1953	3,836,000	1,043,000	396,000	2,910,000	7,117,000	53,000	15,355,000
1954	3,363,000	2,374,000	213,000	3,683,000	6,577,000	21,000	16,231,000
1955	5,407,000	2,152,000	385,000	2,608,000	5,208,000	26,000	15,786,000
1956	5,469,000	1,604,000	322,000	4,260,000	6,357,000	60,000	18,072,000
1957	5,991,000	1,486,000	677,000	3,498,000	5,059,000	48,000	16,749,000
1958	4,172,000	950,000	360,000	2,341,000	8,109,000	209,000	16,141,000
1959	4,524,000	1,070,000	320,000	2,809,000	6,294,000	95,000	15,112,000

* Data from U. S. Fish and Wildlife Service (1942–1959).
§ Not available.

the fish. It has contributed to the increased landings in the New England and Middle Atlantic States which in 1959 totaled 15 million pounds (Table 7). In general the landings in these states during the 1950's were double those for the period from 1939 to 1947. This increase has been largely the result of greater commercial catches in the Cape Cod area and in Rhode Island and New Jersey waters.

Winter returns from fluke marked during the seven tagging operations in the bay and ocean varied from 1 to 7 per cent. These percentages in each case are based upon the maximum number of tagged fluke estimated to have remained in the water on November 1 and the number of returns between then and the following April 30.

RETURNS FROM FLUKE TAGGED IN THE OCEAN

In May 1957, a total of 998 fluke were tagged and released in the ocean east of Shinnecock Inlet. The size composition of these fish was similar to that of the fluke tagged in Great South Bay in the same year (Figure 15). The mean length of the bay fluke was 37.9 centimeters; that of the ocean fluke, 37.2 centimeters. The mode for the bay fluke was 32.0 centimeters; that for the ocean fluke, 33.5 centimeters. They differed in that fish less than 33 centimeters in length occurred more frequently in the bay.

Returns in the summer of 1957 were distributed generally from the Shinnecock-Montauk area to waters of Connecticut, Rhode Island and

Figure 16. Distribution of recaptures during the summer of 1957 for fluke tagged in the ocean east of Shinnecock Inlet in 1957.

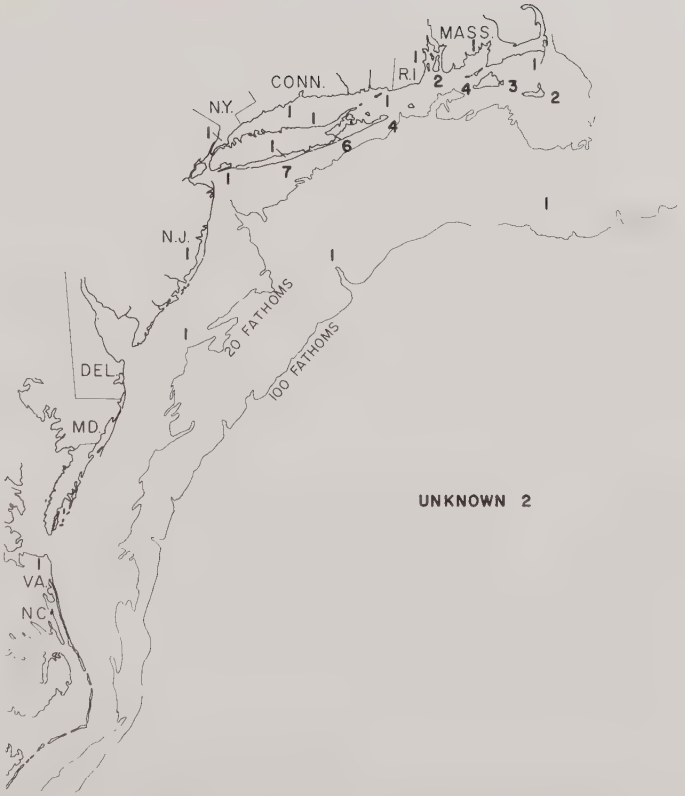

Figure 17. Distribution of recaptures during summer from 1958 to 1960 for fluke tagged in the ocean east of Shinnecock Inlet in 1957.

Massachusetts (Figure 16). Since the movement of the fish was primarily eastward and only two returns were recorded within Shinnecock Bay (where the intensity of fishing would be expected to give adequate sampling) there are indications that commercial fishing during the spring from Shinnecock Inlet to Montauk does not affect sport fishing in Shinnecock Bay during the same year.

Returns during summers subsequent to the year in which the fish were tagged exhibited a drift eastward similar to that which returns from fluke tagged in Great South Bay indicated (Figure 17). However, a tendency for these fish to return to the south-shore waters of Long Island was evident, since 19 of the 44 recaptures in the summers of 1958, 1959 and 1960 were from this location.

During the period from July to early September in 1957 a total of 942 fluke were tagged and released in the ocean east of Fire Island Inlet. The size composition of these fish, compared with that for those tagged in Great South Bay, also demonstrated that fish less than 33 centimeters in length occurred more frequently in the bay than in the ocean during summer (Figure 18). There were 13 recaptures by hook and line within

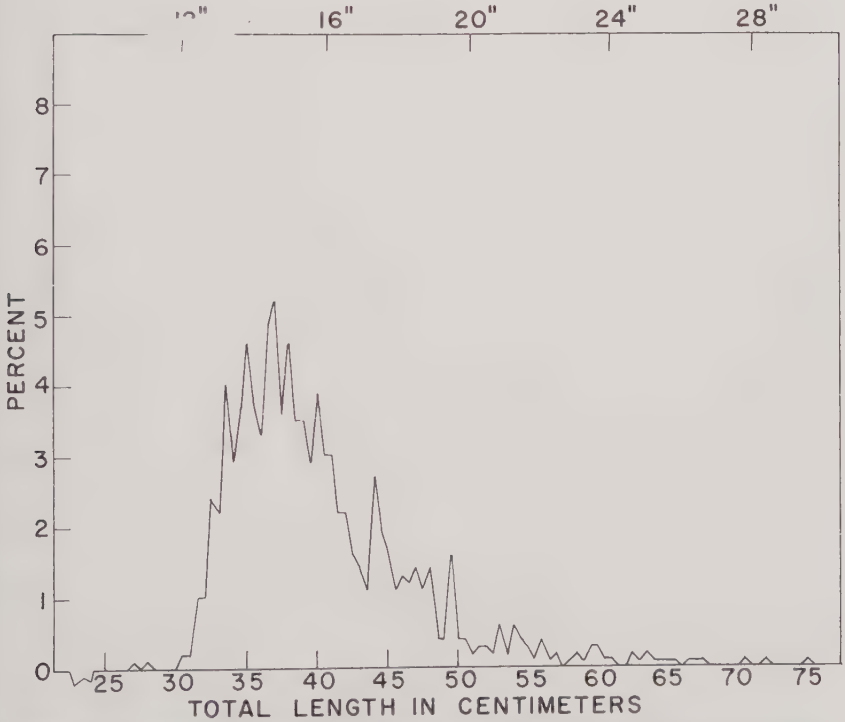

Figure 18. Length frequency of 942 fluke tagged from July to early September in 1957 in the ocean east of Fire Island Inlet.

the inlet, but no returns were recorded from the bay proper (Figure 19). Thus, there was little contribution from fluke present in the ocean during midsummer and autumn to the sport fishery in Great South Bay. This supports similar findings by Westman (1946). Returns in the summer of 1957 totaled 75, all from the south shore of Long Island. Judged from these data, the summer population of fluke in inshore ocean waters was stable and exhibited no eastward drift. Returns in subsequent summers from this ocean tagging program demonstrated a tendency for the fish to return to the waters of Long Island's south shore and to disperse both eastward and westward (Figure 20). Recaptures were more numerous from New Jersey waters (15) than from those of Connecticut, Rhode Island and Massachusetts (4).

From these returns and from those previously described, a pattern of fluke migration appears to be generally definable. The overwintering populations move inshore in early spring to areas near those in which they spent the winter. Once inshore, some fluke enter the bays or stay in nearby ocean waters, and the remainder move eastward. It appears that the fluke off Fire Island Inlet in the summer of 1957 were fish which had migrated in spring to the New Jersey shore and then moved eastward to become the stable ocean population on Long Island's south shore. Recaptures from 500 fluke tagged in the ocean west of Fire Island Inlet during May 1958 support such a pattern of migration. In the summer of 1958, returns were recorded in south-shore bays and generally to the east of the inlet (Figure 21). Returns in subsequent summers also exhibited an eastward drift (Figure 22).

The size composition of the fluke tagged in May 1958 in the ocean demonstrated that at that time of year the smaller-sized fluke had not completely entered the bay waters (Figure 23). In May 44 per cent of the ocean population was composed of fish 33 centimeters or less in length, whereas 7 per cent of the fluke in the Fire Island Inlet area in midsummer and autumn of 1957 were of this small size. From these data, and from the size composition of fluke tagged in Great South Bay, it is evident that during the summer months the bay serves as the primary nursery ground for young fluke. This conclusion is supported by data on the age composition of fluke present in Great South Bay in 1958 and 1959 (Poole, 1961).

Rates of Exploitation and Estimates of Survival

Since the bay is a major nursery ground for fluke and also an area in which the fluke sport fishery is intensive, it is possible that insufficient escapement of young occurs each year. Rates of exploitation by the sport fishery indicate that this is true. In 1956, 1958 and 1959, the rates of exploitation of the fluke population in Great South Bay were 21, 22 and 24 per cent, respectively, for the period from July 1 to September 30 (Table 3). These are minimum values, because not all recaptures of

Figure 19. Distribution of recaptures during the summer of 1957 for fluke tagged in the ocean east of Fire Island Inlet in 1957.

Figure 20. Distribution of recaptures during summer from 1958 to 1960 for fluke tagged in the ocean east of Fire Island Inlet in 1957.

Figure 21. Distribution of recaptures during the summer of 1958 for fluke tagged in the ocean west of Fire Island Inlet in 1958.

Figure 22. Distribution of recaptures during the summers of 1959 and 1960 for fluke tagged in the ocean west of Fire Island Inlet in 1958.

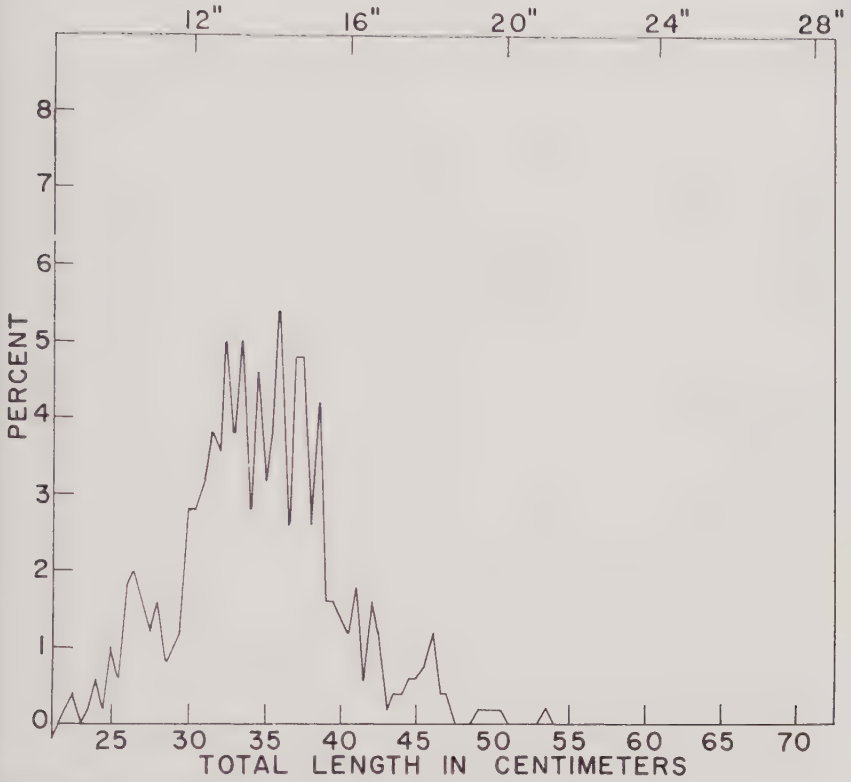

Figure 23. Length frequency of 500 fluke tagged during May and early June in 1958 in the ocean west of Fire Island Inlet.

tagged fluke were reported. When these figures are coupled with survival estimates of the bay population from year to year derived from tagging data, it seems evident that, as a result of the presently intense sport fishery, the developing winter trawl fishery and the expanding summer commercial fishery, the fluke population is being overfished (Table 8). These survival estimates varied from 0.17 to 0.52. Because a given year class in the population of fluke present in the bay was subject to a different fishing rate during the second summer than during the first, due to dispersion to other areas, some question arises as to the acceptability of survival data based on recaptures for the bay populations. However, survival figures based on recaptures from ocean tagging operations were subject to fishing rates of similar magnitude in the first and second years following tagging. Since survival for these approximated those calculated for the bay populations, some degree of confidence can be placed in them.

The estimate of survival of 0.52 for the 1957 bay population and the characteristic return to Long Island waters the following year supports

Table 8. Estimates of Survival of Fluke One Year after Tagging

Item*	1956	1957	1958	1959
Fluke tagged in Great South Bay				
Number tagged	927	1,000	627	851
Number recaptured				
R_1	280	116	208	301
R_2	78	60	64	52
Survival ($R_2 \div R_1$)	0.28	0.52	0.31	0.17
Fluke tagged in the ocean §				
Number tagged	....	998	500	....
Number recaptured				
R_1	....	142	128	. .
R_2	....	28	27	. .
Survival ($R_2 \div R_1$)	....	0.20	0.21	. .

* R_1 represents all recaptures from June 1 to May 31 commencing in year in which fish were tagged; R_2, recaptures during the following 12 months.
§ During May.

the view that management of the fluke is possible without great loss to the bay fishery, i.e., low rate of exploitation in the bay did not cause a higher rate in other areas after the fish had left the bay (Table 5).

GEOGRAPHIC RANGE

On October 10, 1957 a fluke tagged in May of that year in the ocean off Shinnecock Inlet was recaptured by a shrimp trawl in Galveston Bay, Texas. This fish was 39.5 centimeters long when tagged. The recapture was authenticated by U. S. Fish and Wildlife Service biologists at Galveston. On June 1, 1958 a tagged fluke was recaptured by hand spear near the shore at Galveston, Texas. This fish was 48 centimeters long when it was tagged in the ocean off Fire Island on August 8, 1957. There is no reason to believe that this return was not authentic. These returns extend the known range of the fluke beyond the limits previously described as from Maine to South Carolina and possibly to Florida (Bigelow and Schroeder, 1953, p. 269). They are also interesting in that the extension of the range into the western part of the Gulf of Mexico almost includes the southernmost range of two other species of the same genus: *Paralichthys albigutta*, the sand flounder; and *Paralichthys lethostigma*, the southern large flounder. The southern limit for these two species is reported as Corpus Christi Pass, Texas, and their northern limit, North Carolina (Ginsburg, 1952, pp. 325, 329).

CONCLUSIONS

The data obtained demonstrate that recent decreases in fishing success for fluke during late summer in Great South Bay cannot be attributed to

a movement of fish from the bay to the ocean and other bays. Rather, it is due, at least in part, to a high rate of exploitation in early summer by the sport fishery. Management to stabilize the catch throughout the summer seems feasible by limiting in some manner the early fishing pressure. Such management would not result in any great loss in the abundance of fluke through dispersal to other areas.

Great South Bay is a primary nursery ground for young fluke during the summer, and the sport fishery is dependent to a great degree on young fluke. Escapement of the smaller fluke may be insufficient to provide for proper yields of larger fluke. Consequently, there appears to be a need for size or catch limits.

Estimates of survival from year to year indicate that the sport fishery, the winter trawl fishery and the summer commercial fishery are over-exploiting the fluke population at the present time.

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CONTROLLING *ARGULUS* ON AQUARIUM CARP[1]

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ABSTRACT

Tests of five essential oils for selective toxicity toward the copepod ectoparasite *Argulus americanus* indicated that only balsam Peru oil was effective; the others were nonselective, being about as toxic to the host as they were to the parasite at equivalent time-concentrations. Comparative studies of the chemical constituents of these oils disclosed that two esters of cinnamic acid, benzyl cinnamate and cinnamyl cinnamate, were confined exclusively to balsam Peru oil. In further tests no selectivity was ever produced in the absence of chemicals incorporating esters of cinnamic acid, and selectivity never failed to appear in the presence of compounds incorporating these esters.

Practical control of *Argulus* was achieved in 500-gallon laboratory aquaria using 1:25,000 preparations of either balsam Peru oil or benzyl cinnamate. Disinfection in 3 hours, and complete mortality of the parasites in 48 and 70 hours, respectively, resulted. Several limitations are discussed. A reliable criterion of parasite mortality was found.

A recent outbreak of the copepod parasite *Argulus americanus* on carp at the Fish Laboratory at Livingston Manor (N. Y.) necessitated finding an effective method for controlling it in aquaria with volumes of 350 and 500 gallons. The most important effect of this parasite on aquarium carp is that the level of well-being of an infected fish is often lowered to where the animal exhibits loss of appetite and extreme nervousness. Individuals in this condition are unsuitable as experimental subjects. A method was required which would be selectively toxic to *Argulus*, causing the parasites to detach from the carp and producing complete mortality, and yet be harmless to the fish themselves.

Ideally, in order to be suitable, a substance must be selectively toxic to the parasite alone, leaving the host unaffected. Actually this standard was imperfectly achieved, since the fish often were affected during treatment but recovered when the water was freshened or when they were removed to fresh water. However, temporary debilitation and return to normal is a commonly encountered phenomenon in chemical therapeutics. The unique features of the materials found to be satisfactory centered around their ability to produce complete disinfection followed by complete kill of the adult parasite population.

This laboratory is mainly concerned with chemically screening compounds for their effect on fish. Use of the chlorinated hydrocarbon, lindane, was precluded because of the possibility that it might obscure interpretation of observations for standard symptoms produced by a particular chemical being tested. Henderson *et al.* (1959) cited BHC, a commercial formulation of lindane, as the most nontoxic of 10 chlorinated hydrocarbons tested against four species of fish in terms of median tolerance limit. They also stated that needed research on the effects of

[1] A contribution of Federal Aid in Fish and Wildlife Restoration Project F-9-R.

insecticides on aquatic life should include work on identification of toxicants by physiological response of the fish. This implies a physiological response may be expected. If this is the case, until the specific effects are known for a particular concentration of a lindane-bearing substance, a contingency exists which is not desirable when the screening of compounds includes gathering physiological response data.

The possibility that undesirable internal effects on fish could occur also influenced the decision against using lindane. In this regard, Rudd and Genelly (1956) stated that both technical BHC and lindane have been rated as half and one quarter, respectively, the toxicity of DDT, and that, like other chlorinated hydrocarbons, they produce liver enlargement accompanied by necrosis, congestion and fatty degeneration of the liver and kidney due probably to the activity of the organic chloride. Other references to the use of lindane and its commercial formulations BHC and Gammexane as copepodicides have described several other limitations. McNeil (1961) and Sarig and Lahav (1959) described disinfection of fish with lindane in pond treatments which did not produce a complete kill.

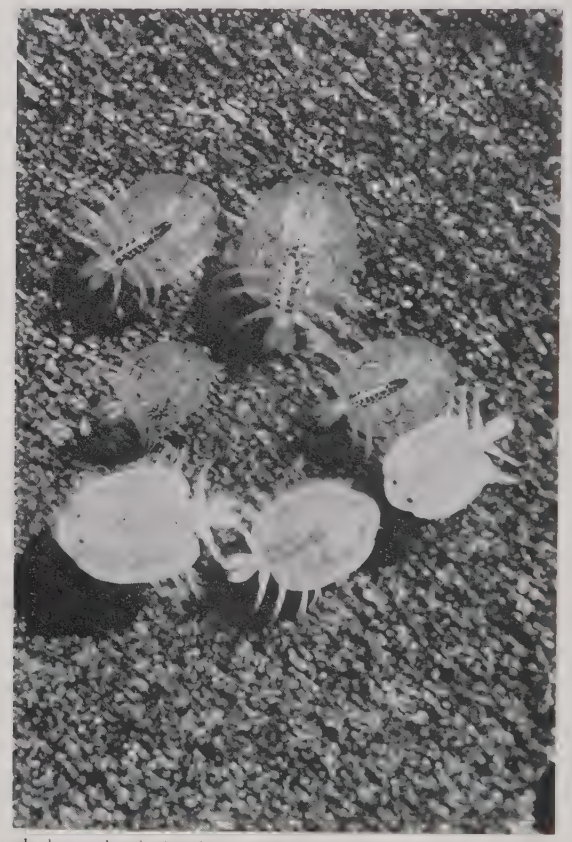
PRELIMINARY TESTS

Preliminary tests of other materials were undertaken to determine their suitability for controlling *Argulus*. Carp taken from the Barge Canal were used; they were parasitized when caught. The tests were run in cylindrical glass aquaria containing 12 liters of aerated water at 65° F. The test water was considered relatively soft. It had a pH of about 6.4, M.O alkalinity of 12.0 ppm, carbon dioxide of 4 ppm and total solids of 23 ppm.

In each experiment, effect on the host, effect on the parasite, and disinfection time, if present, were noted. Effects on both fish and parasite were appraised in relation to a control. Abnormal reactions were considered in terms of increase, depression or cessation of locomotion and respiration. Study of long-term effects on both fish and parasites included observations of locomotion and respiration after they were removed from the treatment baths to fresh water. Also, effect on normal feeding behavior was observed for the fish. A 4-day observation period was usually sufficient because the animals either recovered completely or died in this time. Disinfection time was taken as the time in hours from the start of treatment to the point where all of the parasites became permanently detached from the host.

Effect on the parasite was first noted macroscopically. Since parasites whose leg movements had ceased were often found to recover, microscopic examination became necessary. Even microscopic examination was occasionally deceptive because body fluid and leg movements became imperceptible shortly before death occurred. Observations showed that death occurred as much as 24 hours after movement could no longer be

observed microscopically, or not at all when the parasite was transferred to fresh water or the test solution was detoxified. The most reliable criterion of mortality was the loss of translucence of the carapace and the onset of a dull milky opacity. No parasite, once having exhibited this symptom, ever survived.



Four living and three dead *Argulus;* dead specimens show opaque condition that is criterion of death. (about 3× natural size)

Results

The first experiments involved several commonly used chemicals, i.e., formalin, malachite green, salt and potassium permanganate. Most failed to affect the parasite at all. Only potassium permanganate showed any parasiticidal action, and at 25 ppm this was very low. All were eliminated from further consideration.

The following five essential oils[2] were then tested as emulsions at a concentration of 1:25,000: hemlock oil, American; pine needle oil, Siberian type; balsam Peru oil, ext. genuine balsam; spruce oil, American; and thuja (*occidentalis*) oil, U.S.P. To make the emulsions, 1 gram of the essential oil was mixed with about 300 milliliters of spring water. A slight oil film remained on the sides of the blendor and a second rinse with 300 milliliters of water collected most of this remainder. Water was added to make up exactly 2 liters. Fresh stock was always used, since it separated out if allowed to stand overnight, producing oil globules on the surface and milky slime on the bottom of the container.

Only balsam Peru oil evidenced selective toxicity; the others were nonselective, being about as toxic to the host as they were to the parasite. At a concentration of 1:25,000 it disinfected fish in about 30 minutes. The parasites usually were dead by the 6th hour. The fish were affected somewhat as evidenced by depressed respiration and locomotion, but these effects were not severe. They occurred several hours after carp were disinfected and always terminated a few hours after the fish were placed in fresh water. No mortality occurred when the carp were held in unfreshened emulsions of balsam Peru oil for 24 hours. Exposure to treatment emulsions eventually produced a clear zone at the fin margins and a possible loss of some of the mucous covering of the body. Such fish returned to normal in all respects within a few days. No mortality ever occurred.

All emulsions lost their parasiticidal properties in time. Parasites introduced to a treatment bath 5 hours after the start of the treatment survived. The reasons for loss of toxicity are not known. One possible explanation may relate to the fact that the emulsions disintegrated quite rapidly, producing both surface and bottom film buildup accompanied by progressive clearing of the treatment bath. Experiments with emulsified mineral oil (petrolatum) and corn oil were run to determine whether the physical state of emulsions as a group contributed to their parasiticidal properties. Results were entirely negative.

In these preliminary treatments with balsam Peru oil, disinfection was rapid and the detached parasites were severely debilitated by the 6th hour, showing either very slow or occasional and sporadic leg movement when examined microscopically. Fish discomfort, whenever present, occurred in the first 6 hours. It is not known whether the same constituent which produces parasiticidal properties is primarily responsible for fish discomfort also.

An experiment in water containing 2.5 grams of sodium bicarbonate with balsam Peru oil produced a mortality of only 75 per cent among the parasites as compared with 100 per cent for an identical time-concen-

[2] Manufactured by Magnus, Maybee and Reynard, Inc., New York.

tration in our soft water, indicating that hard water may reduce the effectiveness of the treatment.

Analysis of Components of Essential Oils

Choice of additional chemicals to test for parasiticidal activity was conditioned by a comparative study of the components of these five essential oils. This study disclosed that two esters of cinnamic acid, i.e., benzyl cinnamate and cinnamyl cinnamate, were confined exclusively to balsam Peru oil.

Several additional substances containing either or both of these esters were then tested (Table 1). Benzyl cinnamate (cinnamein), storax and balsam tolu proved selectively toxic toward *Argulus*, while cinnamic acid itself did not.

Cinnamyl cinnamate was not available in pure form for testing. Its chief source is balsam Peru oil and storax where it occurs in company with several compounds including other esters of cinnamic acid. Obviously, cinnamyl cinnamate itself would have to be tested to assign specific parasiticidal activity to it.

Balsam tolu contains many esters of both cinnamic and benzoic acids, as well as being composed (12 to 15 per cent) of the free acids themselves. When tested at a concentration of 1:25,000 it produced a 75 per cent parasite mortality while the fish were normal throughout.

No selectivity occurred in the absence of chemicals incorporating esters of cinnamic acid. Selectivity never failed to appear in the presence of compounds incorporating these esters.

Experiments with Balsam Peru Oil and Benzyl Cinnamate

Final testing was done in 500-gallon aquaria and was limited to the two materials, balsam Peru oil and benzyl cinnamate.

Balsam Peru Oil

Twelve carp weighing 1 to 2 kilograms apiece were treated using a 1:25,000 emulsion of balsam Peru oil. The temperature of the test water was 65° F. and aeration was supplied. Prior to the experiment 14 attachment sites of *Argulus* on six of these fish were recorded, and the fish were individually marked for future recognition. The six marked carp were disinfected for 2½ to 3 hours at the end of which time three *Argulus* held in a live cage in the aquarium showed no leg movements although circulation of body fluids could be observed microscopically. The carp were mildly distressed, and they exhibited depressed respiratory and swimming rates after 7 hours. The inlet was then turned on for 15 minutes relieving the fish of these distress symptoms.

At the 23rd hour all fish were normal in every respect, and the three *Argulus* in the live cage were dead. At the 24th hour, the 12 carp were

TABLE 1. RELATIVE EFFECT ON *Argulus* OF VARIOUS COMPONENTS OF ESSENTIAL OILS

Concentration	State	Effect on *Argulus*			Remarks
		Disinfection time (hours)	Mortality		
			Per Cent	Time (hours)	
			Storax, U.S.P. cleaned		
1:16,700	emulsion	3.0*	80	27	Carp normal throughout treatment. One parasite reattached to fish by 27th hour.
1:36,400	emulsion	2.0	60	19	Carp normal throughout treatment. Surviving parasites remained free of host at 19th hour.
1:144,000	emulsion	*	0	19	Carp normal throughout treatment; disinfection only 50 per cent.
			Benzyl benzoate, N.F.		
1:25,000	emulsion	0.8	20	20	Carp severely affected; slow gilling, motionless on side, much mucous floating; eventually recovered. Surviving parasites remained free of host at 20th hour.
1:50,000	emulsion	1.5*	0	20	Carp initially affected: on side and respiration depressed. Parasites reattached to fish by 20th hour.
			Benzyl cinnamate (cinnamein)		
1:25,000	Tween-alcohol emulsion	0.8	100	22	Carp normal throughout treatment.
1:100,000	Tween-alcohol emulsion	2.0*	0	22	Carp normal throughout treatment. Parasites reattached to fish by 22nd hour.
			Cinnamic acid		
1:25,000	solution	2.0*	0	21	Carp normal throughout treatment. Parasites reattached to fish by 20th hour.
			Balsam tolu, U.S.P. cleaned		
1:25,000	alcohol emulsion	2.0*	75	20	Carp normal throughout treatment. Surviving parasites reattached to fish by 20th hour.

* Disinfection incomplete, see "remarks".

removed from the aquarium and examined individually. No parasites were attached. During the next hour the aquarium bottom was siphoned and 22 *Argulus* were collected. Twenty were confirmed dead using the microscopic determination method described previously, and the two living but immobile parasites were removed to fresh water along with two normal controls. Death of these last two individuals occurred at 6 and 26 hours, respectively, while the two controls remained healthy.

After the 12 carp were permanently removed and the aquarium had been siphoned, three nonparasitized carp were placed in the experimental bath. These three fish were examined for parasites one day later (49th hour) and all were free of parasites indicating that, if any *Argulus* remained on the aquarium bottom after siphoning, they were not capable of re-attaching to a host. However, the evidence suggests that all parasites were dead, since a final siphoning the following day (73rd hour) produced five additional dead *Argulus*, and the three carp remained uninfested.

Benzyl Cinnamate

A fair emulsion was produced by dissolving 79.2 grams of benzyl cinnamate in 400 milliliters of alcohol with 40 drops of Tween 80[3]; this was shaken in a stoppered flask and added directly to a 500-gallon aquarium resulting in a concentration of 1:25,000. The temperature of the test water was 65° F. Eight carp, individually marked and hosting 22 parasites at known attachment sites, were disinfected by the 18th hour. Two initially weak carp were almost dead and were removed to fresh water where they died within 6 hours thereafter. The six remaining carp were severely affected and remained mostly quiet but upright on the floor of the aquarium. They were alert enough to control their swimming movements. After 25 hours, they were removed to fresh water where they soon exhibited normal behavior. Six new, parasite-free carp, put in the treatment bath as replacements, were normal acting and still parasite-free 18 hours later, and siphoning the aquarium bottom thereafter produced 28 *Argulus*. Twenty-two were dead according to the microtechnique previously described. Six displayed barely perceptible leg and body fluid movements when examined microscopically and were removed to fresh water for continued observation. They had all died by the 27th hour, thereby producing a complete kill by the 70th hour after start of treatment.

Effect on Other Species of Fish

It was not practical to perform extensive tolerance studies with respect to other species, but limited work on brook trout (*Salvelinus*

[3] Also called Polysorbate 80 or Poloxyethylene (20) Sorbitan Monooleate; produced by the Atlas Chemical Company, Wilmington, Delaware.

fontinalis), brown trout (*Salmo trutta*) and goldfish (*Carassius auratus*) resulted in the following observations.

1. Benzyl cinnamate at a concentration of 1:50,000 killed brook trout in water at 55° F. in 2.5 hours.
2. Balsam Peru oil severely affected yearling brook trout and brown trout in water at 47° F. in 6 hours, but all survived when removed to fresh water. A 7-hour bath would probably have produced heavy mortality.
3. A treatment with balsam Peru oil at a concentration of 1:25,000 had little observable effect on the lernaeapod parasite of brook trout, *Salmincola edwardsii*. It is, however, very difficult to assess effect unless the parasite actually detaches from the host, a condition which did not occur. Some depression of the rate of body fluid circulation was evidenced upon microexamination, but no other effects were noted.
4. Goldfish usually tolerated the same concentrations that carp withstood.

CONCLUSIONS

Both balsam Peru oil and benzyl cinnamate at concentrations of 1:25,000 were successfully used in 500-gallon aquaria to disinfect carp infected with *Argulus* and to effect control by producing complete mortality among the detached parasites. At this concentration, balsam Peru oil is preferred because it produces less fish debilitation and is easier to prepare. Both chemicals were safe to handle and no special precautions were necessary. In practice, one aquarium was used as a treatment bath, and all diseased carp were placed in it. Empty contaminated aquaria were sterilized with a strong solution of HTH.

Since the fish are somewhat affected, it is necessary to observe the initial part of the treatment closely. The mild distress symptoms which occurred after about 6 hours were quickly relieved by flushing with fresh water. By this time the fish had always been entirely disinfected, and the parasites remaining alive on the aquarium floor never recovered even though the water was freshened. Fish often exhibited normal feeding behavior in the form of continued browsing on the floor of the aquarium during the first 4 hours of treatment. Often the fish had been entirely disinfected when the food search occurred.

Both balsam Peru oil and benzyl cinnamate emulsions proved to be somewhat unstable, separating out at the surface and the bottom of the bath. A better method of preparation is desirable. This separating out of the emulsion may explain the lessening of parasiticidal activity which occurred after the first 5 hours during the preliminary tests.

Further testing is needed to determine whether benzyl cinnamate is satisfactorily effective at some concentration between 1:25,000 and 1:100,000, the latter concentration producing no parasite kill and the

former quite severely affecting the fish although producing a complete parasite kill. Further testing is also indicated with storax at a concentration stronger than 1:16,700, a treatment which produced 80 per cent mortality among the parasites with no adverse effect on the fish.

The cost of balsam Peru oil and benzyl cinnamate (about $10.50 and $3.50 per pound, respectively) and the difficulties encountered in preparing suitable emulsions pose considerable limitations in its use on a pond-treatment scale. The use of Peruvian balsam itself, if effective for treatment, might prove feasible, since it costs about $1.50 per pound.

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EFFECT OF LYSERGIC ACID DIETHYLAMIDE (LSD-25) ON THE SURFACING BEHAVIOR OF LABORATORY CARP[1]

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ABSTRACT

Lysergic acid diethylamide (LSD-25) is a water soluble derivative of d-lysergic acid. For a number of years it has been used in psychiatric work because it causes schizophrenic-type symptoms in man and breaks down inhibitions. Contact doses of 1 ppm or less cause surfacing of Siamese fighting fish, carp and goldfish and probably various minnows. Largemouth bass and brook trout are not similarly affected. Toxic effects of a solution in a laboratory tank lasted for 19 days. Surfacing compounds may be of considerable use in fish management in both sport and commercial fisheries.

Lysergic acid diethylamide (known as LSD-25) has, for somewhat less than a decade, been used extensively in psychiatric work. In doses of several to 100 micrograms per person it produces a disturbance of the personality structure analagous to the schizophrenic-like state in which ego-depression occurs (Abramson, 1956a). Another process, that of ego enhancement, apparently takes place simultaneously. Experience under LSD-25 together with the cooperation of the therapist gives the patient much more confidence in reconstructing and reevaluating data than is possible without the drug (Abramson, 1956b). Large doses cause a withdrawal and almost complete inactivity.

Siamese fighting fish (*Betta splendens*) proved suitable for testing the direct effects of LSD-25 and also of possible antagonists. The effect of LSD-25 on snails and newts has also been noted (Abramson and Jarvik, 1955; Evans and Abramson, 1958). Contact doses of 1 ppm produced surfacing, stupor and other reactions in *Betta*, brought about ultimate death in snails and changed social behavior in newts.

Several other derivatives of d-lysergic acid produce psychic reactions in man. Among them is d-lysergic acid ethylamide (LAE-32), which also causes some surfacing in *Betta*. Still another chemical, Psilocybin, produces surfacing when injected (Abramson *et al.*, 1961).

Success with *Betta* suggested the possibility of causing the surfacing of other species by applying LSD-25 or LAE-32 as a contact dose. It would be the first instance of such effects being produced by chemicals that reacted directly with the fish and caused other than random movements. Other chemicals may cause surfacing by other means. Rotenone affects the gill epithelium and results in suffocation and surfacing of a variable portion of a fish population; sodium sulfite and a few other compounds reduce the oxygen content of water and cause some surfacing of fish. The physiological effects of LSD-25, LAE-32 and Psilocybin are unknown, but tests indicate that the air bladder may be involved. Experi-

[1] A contribution of Federal Aid in Fish and Wildlife Restoration Project F-9-R. Photographs were taken by William H. Kelly.

ments were initiated (by Dr. Harold A. Abramson, Long Island Biological Association, Cold Spring Harbor, New York) on goldfish and later (with the cooperation of the New York State Conservation Department) on carp and trout. Abramson *et al.* (1961) showed that 2-pound carp and small goldfish reacted somewhat similarly to Siamese fighting fish when placed in 2 ppm of LSD-25; they quickly surfaced, remained stuporous for hours and engaged in backward swimming. The experiments were performed with 20- and 40-liter containers. Trout did not surface but became sick enough to vomit. Carp and goldfish did not exhibit some of the symptoms exhibited by *Betta*, such as kinking of the body (Abramson and Evans, 1954).

The surfacing effect of 2 ppm of the closely related drug LAE-32 was also demonstrated with goldfish and carp. This drug took longer to act and the carp did not remain as consistently at the surface as they did with a similar concentration of LSD-25. It is only 1 30 as toxic to man as LSD-25 and can be used more safely.

In order to obtain more data under different conditions (larger water volume, higher temperature, etc.) an additional series of limited experiments were performed at the Conservation Department's Fish Laboratory.

EFFECT OF LSD-25 WHEN APPLIED EXTERNALLY

Fifteen 2-pound carp and two half-pound goldfish were placed in each of two aerated 100-gallon tanks having a height of 30 inches. Water temperature was 70° F., and both tanks were brightly lit from overhead. Figures 1a and 1b show the position of the fish at the bottom of the experimental and control tanks before addition of LSD-25. Figure 1c illustrates the surfacing of the carp in the experimental tank just 3 minutes after 1 ppm of LSD-25 had been added. These fish remained crowded at the surface for more than 3 hours, when all of them were transferred to other waters to observe their recovery reactions.

During the 3 hours that the 15 carp and two goldfish were in the experimental tank they were more or less stuporous at the surface and light colored. These fish exhibited different recovery rates when transferred to other water. Five carp were transferred to a ¼-acre pond, 3 feet deep and having a temperature of 65° F. They remained completely intoxicated at the surface for 8 minutes, either motionless or swimming backward sluggishly. They then became darker and began to respond by sight to people and approaching nets. Within half an hour all fish were normal in color, below the surface and slowly cruising forward. Sight stimuli sent them into mud or vegetation where they had a tendency to stay. For several hours, however, fish could occasionally be seen at the surface, swimming backward but responding immediately to sight stimuli. This indicates either that some LSD-25 was retained within the body or that the chemical produced an effect lasting for some hours.

a. Control fish; bottom position was maintained throughout experiment.

b. Test fish before adding LSD–25.

c. Test fish 3 minutes after adding 1 ppm of LSD–25.

d. Test fish 2 hours after adding 1 ppm of LSD–25.

Figure 1. Surfacing effect of 1 ppm of LSD -25 on 15 carp and two goldfish in 100 gallons of water at 70° F. Control fish were in an identical but separate tank.

In humans the effect also lasts for hours and apparent immunity to future doses of similar size is induced for several days.

Ten carp and two goldfish were transferred after 3 hours from the

LSD-25 solution to a 500-gallon tank. They remained in a horizontal position at the surface for several hours. Color quickly returned to normal, there was no gasping and the mouths were never in contact with the surface. The fish slowly avoided nets and darted when touched, but nevertheless they exhibited continuing evidences of intoxication. Recovery was complete in 6 to 8 hours. Why the fish transferred to a 500-gallon tank should have taken so much longer to recover than those placed in the pond is unknown. One of the fish that had recovered in the pond was placed in the 500-gallon tank (only 25 minutes after removal from the LSD-25 tank); it swam immediately to the bottom where it continued to exhibit only normal reactions. Oxygen concentration in the water was not in question since the LSD-25 tank contained 7 ppm while a somewhat greater amount was present in the 500-gallon tank and in the pond. Experiments were continued for a number of days in order to determine the general rate of loss of strength of the LSD-25 solution and to learn something of development of immunity.

A few minutes after the original fish were removed from the LSD-25 tank six carp and one goldfish were added. In 10 minutes all were at the surface, light colored and in a stupor. Recovery began in a day for the carp, which remained light colored but became more alert and surfaced less and less until they were apparently normal after 10 days. The goldfish did not appear normal until the nineteenth day. On the fifth day a new carp which was introduced rose to the surface in 15 minutes. This fish slowly recovered over a period of 8 days. On the thirteenth day another new carp surfaced in an hour and was light colored but alert. This fish jumped from the tank after one day so that recovery time could not be determined. On the nineteenth day the solution was still toxic. A new carp surfaced in 3 hours but remained dark and alert. This fish recovered in 2 days. On the twenty-second day a new carp was not affected.

As a result of these additional limited experiments it is obvious that the LSD-25 solution steadily became less toxic although new carp initially were affected for about 20 days. Carp became immune to the effects of 1 ppm of LSD-25 after from 10 to 2 days, in proportion to the decrease in toxicity of the original solution. Probably a solution of only 0.5 ppm or even less would have caused carp and goldfish to surface in this water at 70° F.

Very limited data were gathered on the effect of LSD-25 on largemouth bass and golden shiners. Two-pound largemouth bass were placed in the experimental tank with the carp on the fifth and sixth days. Neither fish surfaced and both remained alert but became light colored. One golden shiner was placed in an aerated 1,500-milliliter beaker containing LSD-25 solution from the experimental tank (on the seventh day). In an hour the fish became light colored and showed a tendency to rise. After

2 hours the fish remained at the surface, with quick and irritable movements. Death occurred in less than 24 hours. A control fish remained normal throughout.

EFFECT OF LSD-25 WHEN FORCEFED TO CARP

LSD-25, forcefed in doses of 0.25 to 0.5 milligram per kilogram to each of three carp, caused sluggish movements after 2 hours (1 hour was required for digestion of the gelatin capsule in which the LSD-25 was forcefed), surfacing after 3 hours and recovery after about 22 hours. Throughout the experiment the fish remained alert to movement from above and would dive but immediately return to the surface.

Larger doses of 2.2, 3.5 and 5.5 milligrams per kilogram were more effective. Surfacing, backward swimming and stupor occurred in 2 hours, at which time the fish could not be stimulated by motion or touching. The fish would swim violently when grabbed, however. At the end of 4 hours the fish were sensitive to motion from above and would dive but return to the surface. This continued for 4 hours at which time the observations were discontinued. After 24 hours the fish were completely recovered.

An interesting observation concerned the possible tendency of the three fish fed the larger doses to hide under the boards which covered about 40 per cent of the tank surface. The data are not sufficient for statistical verification, but it appeared that the surfaced fish spent much more time under the boards than in open water. Such symptomatic activity may be analagous to the psychotic symptoms produced by much smaller doses of LSD-25 in man.

EFFECT OF LSD-25 WHEN INJECTED INTO CARP

Doses of 65, 133 and 400 micrograms per kilogram were injected into the body cavities of three carp which were held in a 500-gallon tank at a temperature of 65° F. In an hour the three fish assumed a position several inches below the surface with slight backward swimming. This condition persisted for an hour during which time the fish were completely alert and schooling. Four hours after injection of LSD-25 all fish were normal. These doses did not cause more than slight symptoms of intoxication or any surfacing.

DISCUSSION

A reaction of the air bladder is indicated in connection with the effect of LSD-25 on fish. An immunity to the drug is developed after a period of days but during the period of intoxication the fish are available at the surface of the water. The implications for study of fish and commercial fishing are broad.

For example, population studies might be easier and much less expensive since surfaced fish might be photographed from the air and actually counted. Undesirable species might be removed by netting, shocking or

by lethal chemicals that contaminated only the uppermost strata of water. Commercially valuable species might be taken more economically by surface netting.

LSD-25 is probably not practical for field work, although testing in larger bodies of water would be desirable. This chemical is difficult to obtain at present and is very expensive. Other derivatives of d-lysergic acid may be less costly and one, LAE-32, is much less toxic to man. This is the only group of chemicals that has been demonstrated to cause surfacing of fish by direct chemical action. Tests to date, except for those of LSD-25 on *Betta*, have been limited. The possibilities of the entire group are of interest, in both their biological and economic aspects.

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GROWTH AND FOOD OF WHITE PERCH IN ONEIDA LAKE[1]

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ABSTRACT

Data for 484 white perch from Oneida Lake indicate that the growth rate was high during the first two years of life but that it decreased markedly after age III. Rapid growth of the 1954 year class suggests that the population density was low. Stomach examinations showed that chironomids, mayflies and entomostraca, collectively, were the most important food group.

The white perch (*Roccus americanus*) is a recent addition to the fauna of Oneida Lake (N. Y.). Since white perch populations have had a detrimental effect on sport fishing in some lakes (Richards, 1960; Thoits, 1958), a preliminary study of the species in this lake was undertaken.

PROCEDURE

Scales were taken from 472 white perch caught in gill net sets from 1956 to 1959. Nylon gill nets containing 100 feet of 2-, 2½-, 3-, 3½- and 4-inch stretch mesh were set at 15 sites between mid-June and mid-September of each year. Additional scale samples were obtained from 12 white perch taken by shocking and trap-netting in 1956.

All fish were measured while fresh, and total lengths were recorded to the nearest 0.1 inch. Scale samples were taken at the tip of the left pectoral fin above the lateral line. Plastic impressions of the scales were made, and these were examined on a scale projector at a magnification of 27X. Stomach contents were examined and the occurrence of food items was recorded in the field.

FINDINGS

The 1954 year class was predominant in the gill net catch in four successive years (Table 1). The 1957 year class, which comprised 10 per cent of the 1959 catch, may represent another strong year class. The oldest white perch captured was age VII. Cooper (1941) reported a maximum age of 17 years for white perch in Maine, and other studies have reported age IX and older white perch (Richards, 1960; Thoits, 1958). The Oneida Lake population may be relatively short-lived, or year classes prior to 1954 may have been relatively weak. The latter explanation warrants consideration since white perch may have first entered Oneida Lake about 1950 (Dence, 1952).

[1] Data were collected as a part of Federal Aid in Fish and Wildlife Restoration Project F-17-R (New York). Analysis of the data was supported by a National Science Foundation grant. The assistance of Dr. A. W. Eipper in supervising the data analysis and writing is gratefully acknowledged.

Table 1. Mean Observed Total Lengths (in inches) of White Perch Collected in Oneida Lake, 1956–1959*

Year of capture and sex	Age I+	II+	III+	IV+	V+	VI+	VII+
1956	....	8.35 (43)	8.42 (10)	9.60 (3)	11.70 (1)	....	....
1957	....	8.20 (1)	9.48 (151)	9.12 (18)	8.82 (5)	....	....
1958	6.10 (1)	....	9.96 (7)	9.91 (35)	10.60 (2)	....	....
1959	....	7.91 (20)	8.28 (13)	9.79 (45)	10.33 (124)	10.40 (4)	12.40 (1)
Average	6.10 (1)	8.21 (64)	9.35 (181)	9.71 (101)	10.29 (132)	10.40 (4)	12.40 (1)
Male§	....	7.87 (23)	9.11 (86)	9.48 (59)	9.80 (58)	9.85 (2)	....
Female§	6.10 (1)	8.74 (20)	9.69 (84)	10.03 (42)	10.65 (73)	10.95 (2)	12.40 (1)

* Figures in parentheses are numbers of fish.
§ Weighted means for all years combined; some fish not sexed in 1956 and 1957.

Table 2. Mean Calculated Total Lengths (in inches) of White Perch from Oneida Lake at the End of Each Year of Life*

Year of capture	Age I	II	III	IV	V	VI	VII
1956	3.67 (57)	7.40 (57)	8.21 (14)	9.63 (4)	11.40 (1)	....	....
1957	3.46 (175)	7.40 (175)	8.81 (174)	8.36 (23)	8.30 (5)	....	....
1958	3.57 (45)	7.70 (44)	9.00 (44)	9.66 (37)	10.30 (2)	....	....
1959	3.46 (207)	7.47 (207)	8.93 (187)	9.73 (174)	10.17 (129)	10.58 (5)	12.10 (1)
Weighted mean	3.49 (484)	7.46 (483)	8.86 (419)	9.59 (238)	10.12 (137)	10.58 (5)	12.10 (1)

* Figures in parentheses are numbers of fish.

Observed lengths of white perch from Oneida Lake are shown in Table 1, and calculated lengths appear in Table 2. Relation of total length to scale length was determined from measurements of 484 age I+ and older fish and a sample of 902 young-of-the-year white perch collected by seining during the fall in 1957 and 1958. A linear regression was fitted by least squares to individual body-scale measurements. Length at each annulus was back-calculated using the following equation:

$$\text{total length in inches} = 0.12 + (2.02 \times \text{anterior scale radius in millimeters}).$$

Growth in length was greatest during the first two growing seasons of life and decreased rapidly after age III. Mean calculated total lengths were 3.5, 7.5, 8.9, 9.6 and 10.1 for ages I through V. This growth rate was substantially higher than the statewide growth rates reported for Massachusetts (Thoits, 1958) and for Connecticut (State Board of Fisheries and Game, 1959).

Stomach contents of 431 white perch were examined in the years 1956 through 1959 (Table 3). In each year, chironomids, mayflies and entomostraca, collectively, were the most important food group. But the relative importance of the three food categories within this group varied considerably from year to year. This variation in foods taken in the various collection years probably reflected seasonal changes in food habits. In 1956, 1958 and 1959, most of the fish (62, 49, and 65 per cent, respectively) were taken in July. In these years there was a predominance of mayfly larvae in the stomachs examined. Most of the white perch (62 per cent) collected in 1957 were caught in August and had primarily chironomids in the stomachs. According to Cooper (1941), half the total

TABLE 3. OCCURRENCE OF VARIOUS FOOD ORGANISMS IN STOMACHS OF WHITE PERCH COLLECTED IN ONEIDA LAKE, 1956–1959

Food item	Year			
	1956	1957	1958	1959
Chironomids	3	78	19	32
Mayflies	6	28	32	59
Other insects	0	2	1	2
Entomostraca	4	6	0	39
Amphipoda	3	14	8	5
Fish	0	5	0	4
Other items	2	7	0	3
Number of stomachs examined	15	171	45	200
Number empty	2	56	7	101

volume of food in white perch collected in Maine consisted of mayfly nymphs. Thoits (1958) stated that in Massachusetts white perch consume arthropods, especially aquatic insects, and fish.

DISCUSSION

The catch of white perch in overnight gill net sets increased from 5.5 per set in 1956 to 21.5 in 1959. During these years the 1954 year class constituted 60 to 86 per cent of the white perch taken. The increase in the rate of catch between 1956 and 1959 may have reflected a greater vulnerability of the 1954 year class to gill nets as the average size of the fish increased rather than an increase in population density. Comparatively weak year classes were produced in 1955 and 1956. Rapid growth of the 1954 year class suggests that the population density was low

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DYE-INDUCED EARLY HATCHING OF BROWN TROUT EGGS[1]

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ABSTRACT

Immersion dying with three chemicals, Neutral Red, Nile Blue Sulphate and Bismarck Brown Y, produced early hatching of brown trout eggs. Neutral Red was the most nearly satisfactory. The importance of treating only eggs containing well developed embryos was evident, proper timing of treatment being a critical factor in production of viable fry.

Induced early hatching of brown trout eggs was a rather surprising and potentially valuable by-product of immersion-dying experiments carried on to evaluate the suitability of several dyes for mass marking brown trout (*Salmo trutta*) fry and eggs.

METHODS

Experiments were run using the fish cultural facilities of the Catskill State Fish Hatchery and the chemical facilities of the Fish Laboratory, both located at Livingston Manor (N. Y.). The chemicals used were Neutral Red, Nile Blue Sulphate and Bismarck Brown Y.[2]

The standard procedure for immersion dying included use of cylindrical glass aquaria containing 15 liters of hatchery spring water which, during the 3-week period of experimentation, varied between 43° and 46° F. The jars were placed in hatchery troughs as temperature control baths, and the oxygen supply system comprised an oxygen cylinder connected to an airstone as terminus in the immersion bath. The source and temperatures of water in both dye immersion baths and hatchery troughs were identical, except for an occasional difference in water temperature between the two which never exceeded 2° F.

All eggs used for the experiments were randomly selected from lots for which the date of stripping was known: 200–300 eggs were used for each experiment. They were allowed 10 to 15 minutes acclimation time prior to introduction of dye solutions.

After weighing, dyes were dissolved in an Erlenmeyer flask with a liter of the hatchery spring water as solvent. Relatively insoluble dyes such as Nile Blue Sulphate were best dissolved by dividing the solvent into four parts. The first was then used as the major solvent, and the three remaining aliquots were used as successive rinses for the mixing flask, assuring that any initially undissolved dye particles would eventually be dissolved.

On completion of immersion, both dyed eggs and undyed controls were transferred to trays in a drip incubator. Each tray was screened

[1] A contribution of Federal Aid in Fish and Wildlife Restoration Project F-9-R.

[2] Obtained from National Aniline Division, Allied Chemical Corporation, 40 Rector Street, New York 6, N. Y.

into equal halves, each half receiving either the dyed or the control material. Observations were made daily during the course of the experiments. Water temperatures in the incubator averaged about 45° to 48° F. during the observation period.

It was suggested that early hatching of trout eggs might be associated with presence of an enzyme transmitted from hatching eggs by the water. With this in mind, tests were set up using two designs. The first assured that water used for immersion dying was taken from an egg-free source. The second applied to the period after dying, when eggs were held in the drip incubator trays where hatching eggs of dye experiments were sometimes present in trays above. It consisted of placing both dyed and control eggs in separate halves of each tray. An exotic agent, in this circumstance, would affect both dyed and control lots alike. Early hatching was always appraised in relation to these controls. Also, dyed eggs were always held in the inlet end of the tray, thus affording the opportunity for any enzyme released by early hatching dyed eggs to come in contact with the controls.

FINDINGS

Neutral Red was the most nearly satisfactory of the three compounds tested, and it gave the best results when eggs were immersed in it on the 6th day prior to normal hatching. At a concentration of 4 ppm for 5 hours, a 95 per cent hatch of eggs was produced by the 3rd day following treatment, while a similar hatch did not occur in the controls until the 6th day. During the 3-day interval between immersion and hatching the color faded to light reddish-pink, but the dyed eggs were still easily differentiated from the controls. The dyed fry were a light pink on all body, fin and yolk sac surfaces at hatching, and were still noticeably different from the controls 4 days later. Both dyed and control fry were normal in appearance and behavior during the following 6-day observation period. There was no significant difference in mortality between the dyed and control groups of eggs prior to hatching, or among the fry following hatching.

Treatments with Neutral Red, at the same time-concentration of 4 ppm for 5 hours but 25, 14 and 10 days prior to normal hatching, were much less successful. Eggs dyed 25 days in advance suffered a continuous mortality which reached 60 per cent by the 21st day following treatment when the experiment was terminated. A few control eggs hatched on this day, while the remaining eggs failed to hatch. Abnormal development in the dyed lot was indicated by localized hemorrhage in the blood vessels of the yolk sac (Figure 1). No significant difference in mortality was recorded for the eggs dyed 14 or 10 days in advance. Both lots hatched 4 days early and produced premature embryos lacking the morphology of control individuals which hatched at term. These embryos subsequently suffered a continuous mortality which reached about

Figure 1. Localized hemorrhage in blood vessels of yolk sac 10 days after treatment of brown trout eggs with Neutral Red; eggs treated 25 days before normal hatching.

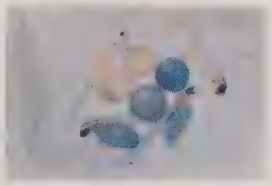

Figure 2. Two brown trout fry which hatched 3 days early after eggs were treated with Nile Blue Sulphate 12 days before normal hatching. Also shown are two fry from control (untreated) eggs as well as two dyed eggs and two control eggs.

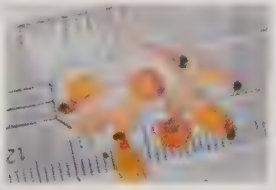

Figure 3. Three brown trout fry which hatched 5 days early after eggs were treated with Bismarck Brown Y 12 days before normal hatching. Also shown are two fry from control (untreated) eggs as well as two dyed eggs and three control eggs.

80 per cent by the end of the first week. Symptoms included marked loss of vigor as well as development of whitish, decayed post-bodies. The latter condition progressed along the body, usually from the tail rudiment anteriorly to about the anal spot, and later frequently included curling of this rear portion to an exaggerated form approaching the semi-circular. The fry from dyed eggs were not different in color from the controls.

Nile Blue Sulphate at a concentration of 10 ppm for 4.5 hours induced hatching 3 days early when eggs were treated 12 days before normal hatching. The eggs were dyed a dark blue-black and the color did not fade. On completion of immersion, one embryo emerged from the egg prematurely. It was dyed deep blue and displayed the degree of embryological development characteristic of this stage. The other fry hatched a dark blue-black and were fairly normal in body shape and vigor at the time of hatching (Figure 2), but they became inactive and 90 per cent died within 5 days.

Bismarck Brown Y at a concentration of 75 ppm for 4 hours induced hatching 5 days early when eggs were treated 12 days prior to normal hatching. This was accompanied by a 90 per cent loss of fry within 6 days. The fry were normal initially but soon became inactive and died. All fry were dyed orange on head, body and fins (Figure 3).

Since the controls consistently hatched on schedule, it was concluded that during these experiments early hatching was correlated with the effect of the dyes used rather than with the presence of an enzyme liberated into the water by prematurely hatching eggs.

DISCUSSION

In the light of evidence presented, the most tenable theory to explain early hatching of trout eggs subjected to dyes is one which includes irritation of the embryo, causing strenuous writhing within the shell, lashing of the tail section and eventual production of shell membrane rupture. The condition and behavior of fry from eggs dyed with Neutral Red 14 or 10 days prior to normal hatching seems to support this theory. Weakening of the shell, by action of the dye itself or by the indirectly stimulated release of shell-softening enzymes by the embryo, seem less probable explanations.

To be effective, with respect to both early hatching of the eggs and good survival of the fry, a dye must penetrate the shell membrane, vitelline components and yolk, and it must be capable of administration at tolerable time-concentrations. Treatment should occur very near the expected hatching date, preferably when the first few normal, advance-hatch fry are noted. Only Neutral Red was tested under these conditions. Both Nile Blue Sulphate and Bismarck Brown Y may also prove useful, since they demonstrated hatch-inducing properties in experiments with eggs at earlier stages containing relatively undeveloped embryos. Other ex-

perience suggests that treatments at concentrations of less than 10 and 75 ppm, respectively, for about 4 hours might be appropriate.

If further work should prove it feasible, induction of early hatching of fish eggs by immersion in suitable chemical solutions may be applicable in several ways. One possibility in hatchery operations is that eggs could be hatched within a much shorter period of time than normal. This kind of chemical "shock" might also be suitable as a technique for culling weak fish. Neutral Red might be used as a short-term sac-fry mark. Eggs immersed in a concentration of 4 ppm for 5 hours on the 6th day prior to normal hatching produced reddish-pink fry, the color lasting 4 days thereafter.

GENERAL NOTES

RED SQUIRREL PREDATION ON A NESTLING COTTONTAIL

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The following observation of predation by a red squirrel (*Tamiasciurus hudsonicus*) on a nestling cottontail (*Sylvilagus floridanus*) was reported to me by Mrs. I. W. Taplin of Slingerlands (Albany County), New York. The incident took place on her property on July 31, 1961 at about 6 p.m. (D.S.T.). A red squirrel ran along the ground holding in its mouth an animal, later identified as a nestling cottontail, which emitted squealing sounds. The squirrel climbed a large aspen to a height of about 25 feet, rested on a limb, and began to feed on the cottontail. After several seconds the prey fell to the ground, and examination by Mrs. Taplin showed it to be still alive although its head had been bitten severely.

Mrs. Taplin showed the rabbit to me on August 2. By this time it had been moved 3 or 4 feet from where it had fallen and had been further mutilated particularly in the head and shoulder region. The distal two thirds of the skull had been removed, all skin and muscle were missing from the remainder of the head and neck, and the shoulders were severely lacerated. Also, a strip of skin had been removed from the forward portion of the back. Although several bites had been inflicted on the hind limbs, the rear half of the animal was considerably less disturbed than the front. It had not been eviscerated. The cottontail's age was estimated at 2 or 3 days.

According to Anthony (1928) red squirrels "appear to be the most carnivorous of our squirrels", while Hamilton (1943) stated that they "have been known to kill and partially devour young cottontails".

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EFFECT OF THE DYE, PLASTO PINK, ON CARP AND TROUT[1]

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Plasto Pink, a water-insoluble dye manufactured by Allied Chemical Corporation, produced a pink coloration of the belly and lower fins when fed to carp at a temperature of 65° F. No coloration was produced by feeding this dye to brook trout and brown trout fingerlings at a temperature of 46° F.

The dye was fed to seven large carp at a rate of 2 per cent in flour-trout pellet-meal baits. The fish were fed as much as they would eat at one time on days 1, 2, 4, 5, 8, 9, 10, 11 and 12 of an 18-day experiment. On the 4th day the fish were slightly pink on the belly and especially on the bases of the pectoral fins. The fish became quite pink in these areas and on the sides, where scales were missing by the 6th day. The coloration was especially noticeable when a fish was examined out of the water. Coloration did not increase between the 6th and 12th days, but after the 9th day the water became pink after each feeding. This suggests that the carp had absorbed a maximum amount of dye and were releasing additional amounts in a soluble form. Color was quickly lost after the last feeding on the 12th day. Three fish were colorless on the 15th day. The others were only slightly pink on the 18th day. Dissection of two fish that were pink on the belly and fins revealed color internally only in the intestines which were pinker than is normally the case.

Four carp were fed one meal of 4 per cent baits and became pink in 4 hours. Two lost all coloring in 3 days, one in 4 and one in 7 days.

A similar feeding with 8 per cent baits also produced color in five fish in 4 hours. Two lost their coloring in 3 days, one in 4, one in 7 and the last in 11 days.

[1] A contribution of Federal Aid in Fish and Wildlife Restoration Project F-9-R.

Fingerling brook trout and brown trout were fed as much 4 per cent Plasto Pink baits and pork melts as they would eat on days 1, 2, 3, 4, 6 and 7 of a 15-day experiment. No external coloring occurred.

Results of feeding Plasto Pink to carp and trout revealed differences due to temperature or specific reaction or both. The dye is the second found to color fish in one feeding and may or may not be useful for short-term marking experiments involving certain species. The other dye, Sudan Black B, causes blue coloration of both trout and carp for months. Plasto Pink produced no short-term symptoms of toxicity.

BREEDING BY A JUVENILE COTTONTAIL RABBIT

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A lactating juvenile female cottontail rabbit (*Sylvilagus floridanus*) weighing 1,170 grams was killed on a road near Cohoes in Albany County on August 11, 1961. That this was a young of the year was determined by the presence of a plate of epiphyseal cartilage in the humerus (Hale, 1949). Examination of the reproductive tract showed five corpora lutea scars on the ovaries and five scars of embryonic attachment on the uterus. This animal had apparently just given birth to five young and had not rebred. Breeding by juvenile females during their first summer has been reported from the Midwest (Cooley, 1946; Ecke, 1955; Lord, 1958) but not from this State (Hamilton, 1940). This represents the first known record for New York State.

During 1961 most first litters of cottontails were born between April 20 and 26. If this cottontail was born in that period she bred at approximately 3 months of age and was approximately 4 months old when she produced a litter.

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